A National Program of Research for

SHEEP AND ANIMALS OTHER THAN CATTLE AND SWINE

Prepared by

A JOINT TASK FORCE OF THE
U. S. DEPARTMENT OF AGRICULTURE
AND THE STATE UNIVERSITIES
AND LAND GRANT COLLEGES

FOREWORD

The United States Department of Agriculture and State Agricultural Experiment Stations are continuing comprehensive planning of research. This report is a part of such joint research planning and was prepared under recommendation 2 (Page 204, paragraph 3) of the National Program of Research for Agriculture.

The Task Force which developed the report was requested to express its collective judgment as individual scientists and research administrators in regard to the research questions that need to be answered, the evaluation of present research efforts, and changes in research programs to meet present and future needs. The Task Force was asked to use the National Program of Research for Agriculture as a basis for its recommendation. However, in recognition of changing research needs it was anticipated that the Task Force recommendations might deviate from the specific plans of the National Program. These deviations are identified in the report along with appropriate reasons for change.

The report represents a valuable contribution to research plans for agriculture. It will be utilized by the Department and the State Agricultural Experiment Stations in developing their research programs. It should not be regarded as a request for the appropriation of funds or as a proposed rate at which funds will be requested to implement the research program.

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This report has been prepared in limited numbers. Persons having a special interest in the development of public research and related programs may request copies from the Research Program Development and Evaluation Staff, Room 318-E Administration Bldg., USDA, Washington, D. C. 20250

September 1969

TABLE OF CONTENTS

PREFACE

Background

The long-range study, "A National Program of Research for Agriculture," conducted by a joint USDA-SAES Task Force, was published in October 1966. A recommendation of the study called for a more systematic and continuing mechanism that would facilitate joint research program planning, evaluation, and coordination. The Agricultural Research Planning Committee recommended the establishment of task forces to develop coordinated State-Federal plans for specified areas of research. Subsequently, thirty-two task forces were established of which this is one.

Authority

The Joint Task Force on Sheep and Animals Other Than Cattle and Swine was appointed jointly by G. L. Mehren, Assistant Secretary of Agriculture, and A. E. Hazen, Chairman of the Experiment Station Committee on Organization and Policy, and announced on March 5, 1968.

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Assignment

The assignment to this task force was to envision the research needs and opportunities pertaining to the sheep and goat industry, the domestic, recreation, fur bearing, or commercial animals other than cattle and swine. Sheep are discussed in Part One under the format used in other task force reports dealing with farm animals. Part Two deals with angora goats, dairy goats, horses, laboratory animals and pets, mink, and rabbits. Other animal species considered include chinchilla, foxes, marten, nutria, and beaver, but information about them is so limited, and their economic importance nationally so small that no discussion is included.

The basis of the report was the applicable research problem areas in "The National Program of Research for Agriculture," sometimes referred to as the "Long-Range Study." In the national program, 10 goals were established to facilitate a systematic approach to determine future research needs. The goals are:

I	Resource conservation and use
II	Protection of forests, crops and livestock
III	Efficient production of farm and forest products
IV	Product development and quality
V	Efficiency in the marketing system
VI	Expand export markets and assist developing countries
VII	Consumer health, nutrition and well being
VIII	Raise level of living of rural people
IX	Improve community services and environment
X	Basic research

Of these goals, only parts of four were assigned for consideration by this task force. They are: II, III, IV, and V. Within Goal VII, one of the research problem areas, 707 pertains to the transmission of animal diseases and parasites to people, and this task force was asked to consider it. It was the opinion of the task force members that none of the diseases affecting the animals considered by this group were very transmissible to man. It was believed that the scientist-man-years projected for the overall program but not assigned to species groups would probably be adequate. Within Goal IX, Research Problem Area 901 pertains to soil, water, and air pollution. Since waste products of wool processing plants are a problem, a statement dealing with that problem is included.

The task force was asked to give its major attention to the research program. Plans for facilities will depend upon the projected program. A facility-study group will have major responsibility in that area. In addition to members of the task force, the report was reviewed by members of the steering committee of the Sheep Industry Development Program and a subcommittee of the Agricultural Research Policy Advisory Committee which was comprised of Federal and State Administrators.

In the final review, several comments were received expressing an opinion that the emphasis on "marketing" and "economics of production" was low relative to other problem areas. It was not possible at this late date for the task force to react to these comments. Also, during the deliberation of the task force it was assumed that RPA 501 dealt mostly with economic aspects of grades and standards. It was later discovered that under RPA 501 the National Program of Research for Agriculture included several physical aspects including: (1) determination of quality characteristics; (2) finding techniques of measurement; and (3) objective measures to replace subjective techniques. To conduct research on these aspects of grading will involve laboratory activities as well as scientific disciplines other than economics.

In view of the above the Co-Chairmen raised the recommendation for 1977 for RPA 313 by 2 SMY's; for RPA 501 by 4 SMY's; and for RPA 505 by 2 SMY's.

S U M M A R Y

PART ONE - SHEEP AND WOOL

INTRODUCTION

A. Importance and Nature of the Sheep Industry

In 1968 there were 22,000,000 sheep and lambs on 200,000 farms in the United States.

Annual sales of sheep, lamb and wool amount to 1% of the cash farm receipts from all commodities . . . lamb makes up 80% and wool 20%.

World sheep numbers have risen from 750,000,000 head in the late 1930's to just over 1,000,000,000 head now . . . world wool production is 6 billion pounds compared with 5-1/2 billion a decade ago . . . 10 countries have 2/3 of the sheep.

1. Geography of Sheep Production

All the states produce sheep . . . Texas is the leading State with 24% of the nation's sheep numbers . . . 80% of the sheep in the U.S. are west of the Mississippi River.

B. Historical Trends in the Sheep and Wool Industry

The nation's peak in sheep numbers of 56,000,000 head was reached in 1942 and declined to 22,000,000 in 1968.

1. Trends in Production

In 1910 over half the returns from sheep production came from wool - now about 20%.

Improvements in production have been limited.

Shearing with chemicals a promising new development.

Wool Act of 1954 provided incentives for wool production with resulting increases for a while then a decline.

2. Trends in Processing and Product Development

Lamb slaughter has shifted from major terminals to supply areas.

Fewer plants now slaughter sheep.

Increased retailer bargaining power has led to more specification buying.

New processing and distribution methods are emerging.

Wool textile mills are shifting from the Northeastern States to the Southeast.

Manmade fibers have become increasingly serious competitors of wool; however, wool has held up quite well.

3. Trends in Marketing

A 1955 survey showed lamb available in only 39% of the nation's retail stores handling red meats.

Promotional efforts have shown that sales of lamb can be stimulated.

Lamb grades became an issue in 1959 leading to revisions of the grades and a research study of their effects. Cutability grades have now been added.

Imports of lamb meat have tripled during the last decade.

Only limited improvements in wool marketing have occurred.

4. Trends in Consumption

Per capita consumption of lamb has declined from a peak of 7.7 pounds in 1912 to 3.7 in 1968, compared with gains for beef and chicken.

Per capita use of wool has declined from a peak of 5 pounds in 1941 to 2.3 pounds in 1968.

C. Activities Aimed At Helping the Sheep Industry

A 1950 study suggested a national sheep flock of 37,000,000 head for utilizing feed and forage resources especially suited to sheep.

A National Wool Act of 1954 provided production incentives and authorized a self-help program.

Promotional activities were conducted and national conferences were held.

The Wool Processing Laboratory was established at the USDA Western Regional Research Laboratory in 1959.

The McKinsey Company was engaged in 1961 to make a study of the industry.

The sheep industry developed specifications for consumer preferred lamb and procedures of preparing wool for market in 1964.

The National Meat Animal Research Center was established in Nebraska in 1964 with 25% of its program devoted to sheep.

The Sheep Industry Development Program was established in 1967 to implement more efficient production and marketing.

D. Research Perspective and Comments

Only recently have increased efforts been made to update the pastoral nature of the sheep industry.

In spite of many pessimistic factors pertaining to the industry there is still room for optimism.

The sheep industry has much un-used potential.

Both lamb and wool are deficit products nationally.

Land and roughage resources are available in abundant supply that would not be used except for production of sheep.

Sheep are capable of converting roughages into a high quality food protein.

Sheep raising and wool production are important in certain parts of the nation . . . it is a farm enterprise that may have potential in rural poverty areas.

Lamb is not available to all persons who might wish to eat it.

Wool still remains unmatched for many textile uses . . . manufacturers of competing fibers find it advantageous to blend wool with their product.

Lamb and wool have not fully satisfied consumers . . . research has helped and offers more help for the future.

Research can help vitalize and rebuild the sheep industry.

A 56% increase in overall research effort is recommended.

A. Protection of Livestock - Goal II

The annual toll of diseases and parasites in sheep is estimated at $60,000,000. In Addition, 1,000,000 head of sheep are destroyed by predators.

Dogs and coyotes are serious deterrents to sheep production--in some areas--repellants or other forms of predator controls are needed.

Internal parasites of sheep cause mortality, reduced yield, condemnation of meat, feed wastage, and expense for drugs.

Poisonous plants are a serious problem--information on many poisonous plants is still incomplete.

Research goals are to control, reduce, or eliminate these impediments and hazards to production.

A 70% increase in research effort is recommended.

B. Efficient Production of Livestock - Goal III

Improved reproductive efficiency will produce more lambs per ewe and more frequent lambing, leading to a more even supply of lamb over the year and increased total supply to better meet consumer needs.

Feed represents the greatest part of cost of production. Feed costs can be reduced and improvements in the quality of lamb and wool can be obtained at the same time.

More information is needed about environmental stress under intensive production--especially with early weaning, confinement rearing, out-of-season lambing, synchronized estrus, and low temperatures after fleece removal.

Increased productivity through genetic improvement would provide a basis for more efficient production.

Improved management systems are needed to increase efficiency of production with scarcity of qualified labor and lack of proper mechanization.

More uniform and better lamb quality would increase consumer acceptance.

A 48% increase in research effort is recommended.

C. Product Development and Quality - Goal IV

Major problems in consumer acceptance of lamb are inconsistent flavor and undesirable odors.

Lack of availability of lamb in many communities is a deterrent to consumption.

New outlets for mutton need further exploration.

More information is needed about the woolen system as a potential for improving outlets for coarser grades of wool.

Improved performance of wool is needed with respect to shrinkage, no ironing, soiling, wrinkle and abrasion resistance.

For worsteds using fine wools, there is need for greater uniformity of raw material and its predictability and repeatability in processing behavior.

More knowledge of blending is needed.

A 41% increase in research effort is recommended.

D. Marketing - Goal V

The relative value of quality attributes of lamb and wool needs to be determined.

Objective, accurate, rapid, and economical means to identify, measure, and describe quality attributes of lamb and wool are needed.

Grades and standards need to be evaluated and kept up-to-date so they accurately reflect value for varying gradations of quality.

Information is needed that will bring about greater efficiency in physical handling of lamb and wool in market channels.

Information is needed on market organization, performance, pricing, competition, market information and consumer attitudes.

A 157% increase in research effort is recommended.

E. Soil, Water, and Air Pollution - Goal IX

Although not the responsibility of this task force, concern was expressed about methods of turning wastes such as lanolin and short wool fibers into useful products and avoiding pollution of streams.

PART TWO - ANIMALS OTHER THAN CATTLE, SWINE, AND SHEEP

This section of the report deals with:

Angora Goats	Laboratory Animals and Pets
Dairy Goats	Mink
Horses	Rabbits

Although these animals have had only limited research, they offer opportunities for increased pleasure and/or income.

The Animal and Animal Products Research Advisory Committee has emphasized the need for research on rabbits for use in medical research.

Much of the research classified in this category is basic in nature and has the potential of being applicable to several species of animals and possibly humans.

A. Angora Goats

These animals are kept primarily for mohair production. Mohair is a smooth, strong, durable and resilient fiber which adds softness and luster to fabrics.

Goats prefer woody plants and help maintain a better balance of vegetation than when cattle and sheep are grazed without goats.

Reproductive problems, especially abortion, are a major concern.

B. Dairy Goats

Small herds of goats are kept primarily for milk production, often in the vicinity of large cities.

Goat's milk is healthful and nutritious, easily digested, well suited for infants and invalids.

Major research opportunities are to increase milk production and the number of off-spring.

C. Horses

For centuries horses have furnished the means of power and transportation for man. In the United States, horses were largely replaced through mechanization, but have made a come-back for pleasure uses.

Major research problems pertain to reproductive efficiency, nutritional requirements, diseases, management, training, breeding for more easy handling, lameness, and unsoundness.

D. Laboratory Animals and Pets

More than 58,000,000 research animals were used in 1966.

There are over 1500 known users of laboratory animals.

More than 130 different kinds and species of creatures are used . . . They include - rodents, rabbits, primates, birds, marine animals, dogs, cats, frogs, insects, and others.

An estimate of the number of animals used as pets stands at 26 million dogs and 32 million cats with a probable value in excess of $1,000,000,000.

The 1966 Laboratory Animal Welfare Act assigned responsibility to the USDA for enforcing necessary standards of care . . . .

Major research problems are the determination of what constitutes a proper standard of care for laboratory animals; to improve and increase their use and effectiveness through breeding, feeding, and management, and to prevent or control diseases and parasites affecting pets and laboratory animals.

E. Mink

Following World War II about 2,000,000 mink pelts were produced in the U. S. This figure has grown to 8,000,000.

Between 5 and 6 million pelts are imported and about 1,000,000 exported . . . about 40% of pelts consumed in the U. S. are imported.

During the early years of mink production mutant genes were discovered which have made it possible to provide a range of colors from almost white to black with many attractive colors in between.

Mink apparel is the dream of every well dressed woman . . . and has been used by royalty down through the ages . . . mink furs are not only beautiful but are light in weight, versatile, durable, and easy to style.

Production of mink occurs on some 4,000 ranches located mostly in the Northern States . . . mink utilize by-products of the meat, poultry, and fishing industries and consume surplus feeds . . . employment is provided for about 10,000 people on ranches and in related industries.

Foreign competition is intense . . . . American pelts are superior in quality but hardly enough to offset higher costs of production.

Major research problems are diseases, feed efficiency, reproductive efficiency, environment and the need for objective measures of pelt quality.

F. Rabbits

Breeds of rabbits from other countries furnished the foundation stock for six breeds developed in the U. S.

The major center of production has been California, dating back to the 1920's but in recent years Arkansas has become important.

Production has been largely for meat and skins, but lately the production of biological material for medical research has increased.

Domestic rabbit compares favorably with other meat-producing animals and poultry . . . a doe will produce 4 litters a year with about 8 young weaned in each . . . young fryer rabbits will weigh from 4 to 5 pounds at 2 months of age and yield over 50% of carcass meat of which 80% is edible . . . a pound of marketable fryer will require from 2-1/2 to 3-1/2 pounds of feed.

It is estimated that between 8 to 12 million fryers are produced annually in the U. S. valued at some $10,000,000.

Major research problems are diseases and environmental stress.

I. INTRODUCTION

In order to make meaningful recommendations regarding a research program for the sheep industry it was believed worthwhile to develop a brief perspective of the industry's setting in the national economy, including some of the important historical developments. This perspective includes trends that took place in production, processing, marketing, and consumption, and some of the major activities of the industry in efforts to help itself, and lastly some of the overall aspects that pertain to the research program--the purpose of this report.

A. Importance and Nature of the Sheep Industry

In 1968, sheep were produced on about 200,000 farms in the United States. Sales of sheep, lamb, and wool make up about one percent of total cash receipts from all farm commodities, with sales of sheep and lamb contributing about 80%, and wool about 20% of the amount from that source. During the last several years the farm value of sheep and lambs sold was approximately $300,000,000 and between 75 and 100 million for the wool. Wool prices in 1966 were the second highest since passage of the Wool Act in 1954. In the process of sheep production, three joint products are produced simultaneously--meat, wool, and skins.

In a broader perspective, sheep and wool are produced throughout the world. Ten countries account for almost 2/3 of the world total. The seven leading countries in sheep numbers in order of importance are: Australia, the Soviet Union, Red China, New Zealand, Argentina, India, and the Republic of South Africa. The United States ranks eleventh. During the last 3 decades world sheep numbers have risen from about 750. million head in the late 1930's to 991 million in 1960, then have declined temporarily, and have since risen to slightly over one billion head. World production of wool is just under 6 billion pounds, compared with about $5\frac{1}{2}$ billion pounds a decade earlier.

Although sheep and wool production are increasing over the world, it is at a slower rate than the human population. Sheep numbers are increasing or remaining stable in the Southern Hemisphere and Eastern Europe, but are decreasing in Western Europe, Asia, and North America.

1. Geography of Sheep Production.--Sheep are produced in all states. Texas is by far the leading state with 24% of total sheep numbers. The 11 Western states have 40% and the 7 West North Central states have 24% of total sheep numbers. Eighty percent of the sheep in the U. S. are found west of the Mississippi River. There are two major and significantly different production areas: (1) the western range states, and (2) the states where sheep are produced mainly under farm conditions they include all but the 11 western states, Texas, and South Dakota.

2. Public Services and Regulations.--The sheep industry operates within a framework of services and regulations that require and offer opportunities for research. Among these services are inspection and quarantine to prevent foreign diseases from entering the U. S. through imports; inspection at public stockyards to control diseases; meat inspection at slaughter plants for meat entering trade to protect consumers; packers and stockyards act to preserve free and open competition for livestock in the market place; market news to provide information to buyers and sellers of livestock; and standards and grades to facilitate trading through a common language that describes quality and other product attributes to enable buyers and sellers to establish value differences for varying gradations of quality. (For a brief description of these services see Appendix A.)

B. Historical Trends in the Sheep and Wool Industry

During the past 60 years sheep numbers at first declined for about 15 years and then quickly increased. In 1930, there were 50 million head on 584,000 farms. Our peak of over 56 million head was reached in 1942. Labor problems and unfavorable prices during and following World War II led to a rapid decline to a low of less than 30 million head in 1950. Numbers remained around the 30 million level and increased to almost 34 million in 1959. Beginning in 1960 numbers have steadily declined to the present low of about 22 million head on 200,000 farms.

1. Trends in Production.--The most significant trend in production has been the decline. Historically sheep production has been pastoral in nature. Sheep producers have not adjusted as rapidly as producers of many other agricultural products to modern highly efficient and mass production techniques. Some of the factors which contributed to the decline in sheep production include: (1) a sharp drop in lamb prices in 1961 and 1962 and a slow recovery since that time; (2) difficulty in obtaining adequate and dependable labor; (3) severe losses from predatory animals; (4) drought in some areas; (5) continued reductions on Federal grazing lands; and (6) shifts to other livestock and alternative farm enterprises. It is interesting to note that a study of the sheep industry in 1950 cited most of these same reasons for declining sheep numbers.

Sheep producers have tended to pay more attention to lamb production and less to wool production as the relative returns from lamb and wool have changed. In 1910 over half the returns from sheep production came from wool. Now only about 20% of the returns from sheep come from wool although in the Southwest the relative importance of wool is higher.

Improvements in production have been limited. Lamb production, as measured by the number of lambs saved per 100 females of breeding age, increased from 87 in the 1920's to 93 in the 1950's with no consistent improvement since 1955. With sheep 100 is not a ceiling--increased

multiple births could raise the level substantially. Wool production increased slightly--fleece weights were about 8 pounds in the 1940's; 8.4 in the 1950's; and 8.5 in the 1960's.

Lambing rates vary with the season bred, with nutrition and management, and breeds and breeding. Attempts to produce lambs at all times of the year, to produce more than one crop per year and to increase lambs born per lambing have met with only limited success. Up to 1/4 of ewes fail to become pregnant. Lamb mortality occurs before, during, and after birth, amounting to 20% or more from birth on. In the face of these problems the sheep producer has acted where he could to produce more efficiently. Labor costs have been reduced by fencing in many range areas. The market weight of lambs has been gradually increased thus increasing the volume of the product relative to ewe maintenance costs. Increasing attention has been devoted to increasing lambs produced per ewe, and to breeding for more rapid growth rates and heavier fleeces. However, in many cases the knowledge and methods required to increase efficiency of production are lacking.

A recent research development that offers promise for wool production is the possibility of shearing sheep with chemicals. The chemicals interrupt cell growth in the bulb of each wool fiber, causing a ringlike constriction. The constriction moves up from the bulb of each wool fiber as it grows and in 6 to 7 days reaches a position just below the skin surface. At that point the fiber breaks easily and the whole fleece can be separated, or defleecing can be delayed until a short growth of new wool forms below the constriction point so the new coat will give the sheep some protection from the weather. In addition to a substantial saving in labor costs the chemical shearing does not leave nicks and cuts on the skin and prevents second cuts of wool. Further studies are necessary to determine whether chemical defleecing is economically practical and whether it causes chemical residues in the meat or alters wool growth or quality.

A number of actions have been taken to strengthen the sheep industry and to reverse the trend in sheep numbers. The National Wool Act of 1954, since extended, has provided for incentive payments to encourage domestic production of wool. By making the payments on a percentage basis, growers are encouraged to improve the quality and marketing of their wool to obtain the best price possible, because the higher the price the individual grower gets in the free market, the greater his payment.

2. Trends in Processing and Product Development.--Under processing we are mainly concerned with physically changing the form of the product, where and how the processing is done, and some of the implications that might influence future research programs. Lamb slaughter has shifted away from some of the former major centers such as Chicago, St. Louis, New York, Cleveland, and Kansas City because of difficulties in procuring steady supplies and because of changes in the relative

transportation costs of lambs and meat. It is now concentrated in areas closest to major supplies. Efficient operations require a steady flow of considerable volume to keep unit costs at a minimum. Older plants have been shut down because of obsolescence, high labor costs, and lack of steady supplies. Modern plants have been opened in other areas and some plants remodeled to utilize labor-saving equipment and new cost-cutting processes.

a. Lamb

The total number of slaughtering plants in the U.S. for killing sheep and lambs declined from 1,227 in 1955 to 1,115 in 1965. During the same period the number of Federally inspected slaughter plants declined from 222 to 152. These plants handle approximately 89% of total lamb and sheep slaughter. The number of plants handling only sheep and lambs increased from 5 to 18. This is in keeping with the trend in industry to concentrate slaughtering capacity in more specialized operations. During the first half of the 1960's purchases by packers directly from country dealers increased from 49% to 65%; purchases at terminal markets declined from 35% to 22% and at auction markets from 15% to less than 14%.

Processors are faced with a much more discriminating market than formerly. Consumer demand for lean, tender, flavorful meat with a minimum of fat is causing retailers to specify the kind of products they will handle. As retailers have become larger, their bargaining power with processor-suppliers has increased. Twenty years ago 1,000 lamb carcasses might have been sold to 50 different retail customers by a packer route salesman, whereas today, large volume orders are placed by telephone at an agreed-upon price according to an understood set of specifications.

Some recent innovations in lamb processing and distribution may be illustrated in the operation of a progressive processor in a western state. His philosophy is that too much emphasis has been given to why changes should not occur and too little to exploring what needs to be done to meet modern conditions. He looks with favor on yield grading as a means of providing a yardstick to measure the carcasses which in turn offers an opportunity to charge a little more for the best product. His firm considers lamb a specialty item for the reason that it does not move through marketing channels in large volume like beef, pork, or poultry and less than half the supermarkets and less than half the purveyors have a consistent supply of lamb. Retailers have trouble merchandising the whole carcass. Many retail butchers have limited experience in cutting up a lamb. By breaking and fabricating

at the processing plant he is able to sell retailers the cuts they can merchandise. By packing his products in a vaccuum package they have enough shelf life to give the retailer more time to move them in trade. He has a goal of shipping a customer-retailer only what he wants and can best sell. His firm is exploring a consumer package--complete with brand name and how-to-cook instructions--perhaps fresh now but probably frozen in the future if and when the market will accept it. Also, in looking to future marketing opportunities he predicts there will be renewed emphasis on improved carcasses and more steady and dependable sources of supply from producers and expanded outlets including institutional use such as hospitals, plant cafeterias, and school lunches.

b. Wool

Turning to wool, the United States produces about 3% of the world supply. Throughout the world somewhat over 75% is used for apparel and the balance for other uses. The use-pattern in the U.S. is about the same. Nonapparel use includes carpets, blankets, upholstery and drapery fabrics.

Production of shorn wool in the U.S. in 1968 was 6% less than in 1967 continuing a decline of 8 years. The present level is about 1/3 below the most recent high in 1960. Production in 1968 privided about 43% of our needs for apparel wool leaving 57% to be supplied by imports. Thirty years ago we produced 60 to 70% of the wool consumed in the U.S.

Most of the mills manufacturing wool products have been in the northeastern States. Much of the machinery in these old mills was obsolete and labor costs were rising. During the last two decades a number of new mills equipped with modern machines have been established in the southeastern States. These new machines and improved procedures have enabled manufacturers to reduce costs of operation. Also, they could shift from one fiber to another for a more flexible operation and for blending. To operate efficiently the modern high speed machines with many automatic operations require highly uniform fiber stock. Poorly prepared wool has met with increasing disfavor by manufacturers. As a result of this shift in location of mills, large volumes of grease wool are shipped from the West to New England and Middle Atlantic States for scouring, and then reshipped to the South for processing into yarns and fabrics. Western commission scourers have located plants in Texas and the lower Rocky Mountains to try to intercept these shipments.

After scouring to remove dirt and grease from wool it goes into two main processing channels, worsted and woolen. The worsted process uses the long fibers and the woolen process uses the short fibers. Rayon has been used in fabrics since the 1920's. By 1940 other man-made fibers were making inroads on the fiber market.

Per capita use of textile fibers provides a convenient indicator of trends. In 1968 a new record was set for total per capita use of all fibers at 50.9 pounds. The biggest upsurge occurred in the noncellulosic man-made fibers--from slightly over 4 pounds per person in 1960 to 18 pounds in 1968. The biggest loser in total volume was cotton--where the trend has been downward from a peak of 40 pounds per capita in 1942 to 22 pounds in 1968. Percentage-wise, the decline for wool was about the same as for cotton--from a high point of 5 pounds per person in 1941 to 2.3 pounds in 1968 with the low point in 1967 at 2.1 pounds. Rayon and acetate use per capita reached a high of 8.6 pounds per capita in 1950 and the same again in 1968 with slightly lesser amounts during the intervening years. (See Appendix Table 1 for additional details.)

Significant price declines have occurred for the man-made fibers. Between 1954 and 1968 the following price declines occurred in the noncellulosic man-made fibers: nylon 37%; orlon 53%; acrilon 40%; and dacron 62%. These compare with a 23% decline in average price received by wool growers.

In spite of these developments wool has held up quite well and is still preferred for certain uses. Wool has maintained superiority in tailorability, comfort in wear, appearance, and hand or "feel," but consumers prefer garments that hold their pleats and creases, resist shrinkage and wrinkling during washing, and dry quickly. Research has been an important factor in helping wool hold up as well as it has in the face of the increasing competition.

3. Trends in Marketing.--The concept of marketing as used here is mainly buying and selling--change of ownership. Many of the changes in processing discussed in the preceding section affect marketing, as does the production of the raw material. Transfer of ownership usually occurs both before and after processing. The changes that have taken place in assembly of raw material, transportation, storing, price determination, competition, merchandising, and distribution will likely influence future marketing research. Again the most significant trend has been the decline in lamb and wool production and consumption.

As a result of our experiences in World War II, Congress declared wool an essential and strategic commodity which was not produced in sufficient quantity to meet domestic needs. As a measure of national security a goal for wool production was established. The National Wool Act of 1954 was enacted, which included an industry self-help program. The Act provided for payments to producers as an incentive to increase the domestic production of shorn wool to 300 million pounds annually. In 1955 the shorn wool production was 241 million pounds. Ten years later it reached a peak of 265 million pounds, but has since declined steadily to 178 million pounds in 1968.

The role of wool as a strategic material is not clear at present. In recent years we have been moving away from the annual goal rather than

closer to it. Until well into the 20th Century wool dominated the military uniform. However, other fibers have displaced wool until today it is largely restricted to service and dress uniforms and few field items. The decline became important early in World War II, when cotton replaced wool as the basic outer fabric for field uniforms. The experiences of World War II made it obvious that the outer layer of cold-weather clothing had to be water repellant and wind resistant. Cotton fabrics, which could provide these characteristics and also resist wear and tear, replaced wool in the shield layer of the field uniform. Wool then assumed the role of insulation, for which it is eminently qualified. Stories are told of the suffering of Hitler's armies from the bitter cold on the Russian front during World War II because of ersatz material in their clothing. It is believed that the Russians had considerable wool in their uniforms. Although we hope such a global conflict as World War II will never recur, the experience of being shut off from foreign wool supplies was still fresh in mind when Congress passed the Wool Act. Since 1962 statistics have been reported on deliveries of textile fabrics to U. S. military forces, but the time period is too short and the quantities too erratic to provide an indication of trend.

The Wool Act further provided for pro rata deductions from incentive payments to producers to enable sheep and wool growers to establish an advertising and sales promotion program aimed at increasing the demand for their products. In February 1955, a new organization known as the American Sheep Producers Council was created by organizations of sheep, lamb, and wool producers to take advantage of the provisions of the Wool Act. The ASPC encouraged research aimed at marketing problems.

a. Lamb

During the latter 1950's and early 1960's a succession of studies was conducted to determine the availability of lamb in stores throughout the nation, how it was merchandised and distributed, the effect of promotional programs, consumer preferences and attitudes, and the economic effects of U. S. grades for lamb. It was found that lamb and mutton were more unevenly distributed throughout the United States than most agricultural commodities.

A survey conducted in October 1955 indicated that many potential retail outlets for lamb did not handle the product. Lamb was available in only 39% of the retail stores handling fresh red meats across the Nation. In the Northeast, 73% of the stores selling fresh red meats carried lamb; in the West 54%; in the North Central region 33%; and in the South 17%. Of the stores selling lamb, over half received deliveries in the form of whole carcasses, and over half the stores reported difficulty in selling certain cuts, principally breast, flank, and neck. Per capita consumption was highest in Massachusetts and California where it exceeded 12 pounds compared with less than 1/2 pound in some areas of the midwest and the south.

To help solve the problem of lack of availability of lamb it was recommended in the McKinsey report that the domestic supply of lamb might be supplemented with a controlled import program. Imports of lamb meat have tripled during the last decade.

Demand studies have shown that consumers are highly sensitive, in terms of purchases, to changes in the price of lamb. That is, any change in the price of lamb usually brings about a significant change in the quantity purchased. The promotional efforts of the American Sheep Producers Council have demonstrated that sales of lamb can be stimulated in a given market. These experiences also pointed out the difficulty of promoting a product which does not fully satisfy the consumer and the futility of promotional programs where there is no lamb available.

The influence of Federal grades for lamb became an important issue in 1959 as they affected marketing activities. For approximately four decades a voluntary Federal grading service has been available for lamb and mutton carcasses. Sheep have the ability to produce meat from roughage, but many western wool-type lambs did not readily meet the conformation standards of the existing grades without extended feeding. The feeding caused the addition of fat which was objectionable to consumers. Also lamb feeders were disappointed when their lambs were discounted in the market for being overweight and failed to make the desired grade.

Early in 1959 several groups in the sheep industry asked the Department of Agriculture to suspend Federal grading of lamb. The situation led to public hearings before the House of Representatives Committee on Agriculture in January 1960. It was recommended that grading be continued but that grades be reviewed and that a study be made of the effect on prices. Grade standards for lamb and mutton were revised, effective March 1, 1960. Changes in the standards were brought about by reducing both the conformation and quality requirements for the prime and choice grades. In general, the revised grades put less emphasis on fat or "finish." The study on economic effects of US grades for lamb furnished factual information that was very helpful in resolving this issue in terms of the public interest. The general conclusion was that despite imperfections, Federal grades for lamb are useful at all levels of the market and have important beneficial effects. There was no evidence that they were responsible for the problems troubling the industry, expecially since the use of grades is voluntary.

A few additional highlights of the study included: . . . Lamb prices are more affected by changes in the supply of beef than by changes in the supply of lamb . . . Federal grades have their own price effects . . . they promote competition . . . they facilitate trade and lower marketing costs . . . the consistent availability of a standardized product tends to increase consumer acceptance . . . helps the pricing system direct production . . . . Federal grades are not a private franchise but are available to all packers . . . independent packers can use them to compete effectively with national packers with private brands . . . a

method of stratifying products on the basis of quality . . . buyers and sellers have more information . . . changes that lead to production of a better product and expand the market are in the producers' interest . . . continued research is needed to identify lamb characteristics which provide greater consumer acceptance . . . further changes in lamb standards may be necessary.

The most recent development affecting lamb marketing was the adoption on March 1, 1969, of yield grades for lamb carcasses and slaughter lambs. In 1964 an Industry Planning Committee announced an industry-wide goal of "Consumer Preferred Lamb." The ideal carcass was defined as to weight, quality, meatiness, and fat covering. It is essentially one that combines thick muscling, a minimum of excess fat, and a high quality of lean meat. The yield grades should contribute toward achieving the industry goal by making it possible to identify these lambs and their carcasses in the marketing process.

The new yield grades are based on many years of research by USDA and a number of State universities. They provide a uniform method of identifying cutability differences among lamb carcasses and slaughter lambs. Five yield grades will be used with Yield Grade 1 having the highest yield of retail cuts and Yield Grade 5 having the lowest. In cutability tests, a difference of about $13 per hundred weight in total retail carcass value was found between the highest and lowest yielding carcasses within the choice grade. Also, based on retail pricing data, the range in yields of cuts within a yield grade (1.8 percent) represents a difference in retail sales value of about $3.40 per hundred weight. The use of the new grades will be entirely voluntary as in the past with the quality grades. This development should be in the interests of the sheep industry by enabling producers to more clearly understand the exact desires of consumers and to make it possible for the marketing system to provide payment for lambs in line with their actual value.

b. Wool

Most shorn wool is marketed through warehouses. In this respect wool marketing is similar to that of tobacco with a great deal of subjective judgement and personal involvement in the buying and selling transactions. Only limited improvements in marketing have been made over many years. Among the services that may be offered by warehouses are: grading, sampling, transporting, core testing, and baling. Warehouses rarely offer the services of sorting or scouring. There is great diversity among warehouses as to which services are provided.

Local wool pools are also an important marketing agency in some areas of the U. S., particularly in the eastern states where sheep are scattered and the numbers relatively small. Their volumes handled are usually quite small and few, if any, services are offered except assembly and sales. Local pools generally lack trained management and organization stability.

Two developments that affect marketing are taking place--increased use of truck transportation for long hauls, and more baling. The increased trucking grew out of the baling development. About 1953, a new system of baling was developed in Texas by a trucking firm. By the late 1950's most of the wools from Texas and southeastern New Mexico were baled and transported by truck. Since 1955, baling throughout the US has greatly increased. Before baling, railroads provided most long-haul wool transportation because of the bulk involved. Advantages of trucks are faster delivery and ability to deliver at more than one mill or warehouse in a market area.

Successfully scouring wools nearer their production area, thus eliminating the shipment of waste material and reducing transportation costs, has come about since the early 1950's. However, many problems are involved. Members of the wool trade have long maintained that scouring wools for growers, wool dealers, or other nonprocessor accounts may limit the market outlets for these wools, regardless of their length, to woolen manufacturers--nearly always a lower priced market than worsted manufacturers. This is because processing requirements for worsteds are particularly rigid, and once wools are scoured it is extremely difficult to determine their various quality characteristics and among other things, how efficiently they will comb. For these reasons, topmakers and worsted manufacturers buy grease wool almost exclusively.

Historically, transportation tended to establish monopolies within the warehouse industry, as growers usually took their wool to the nearest warehouse. As the transportation system has improved, growers have sent their wool to the warehouse that provided the greatest net benefit. The transportation system is now limiting monopoly power instead of establishing it.

Before 1920, wool was seldom graded at the grower level. Since then this practice has become common and is usually done at the warehouse where the wool is sold, or in some instances at the shearing pens.

The sorting operation has traditionally been carried out by the topmakers and manufacturers. They maintained that sorting must be guided by the specific yarn or cloth types to be produced. The general tendency has been toward less sorting because it is done by hand and is slow and expensive.

The most common problems of warehouse operators are: (1) inadequate volume; (2) lack of suitable facilities and equipment; (3) lack of insurance at reasonable cost; (4) inability to determine the most effective merchandising methods; and (5) inadequate classification and market information services.

4. Trends in Consumption.--During the last 15 years the proportion of the consumer's dollar spent for food has declined from 22% to 18% and for many foods the consumer is getting higher quality, better packaged, and more convenient foods. The choices made in retail food stores signal to marketers and hence indirectly to producers what the preferences are in terms of quality, convenience and price. In this ever-changing and highly competitive situation lamb has not held its own over the years. Statistics of the last 60 years show a high point in 1912 of 7.7 pounds of lamb per capita. Five times between 1920 and 1945 per capita consumption reached 7 pounds or more. Since then the trend has been gradually downward to a low point of 3.7 pounds in 1965, up some in 1966 and 1967 and back to 3.7 in 1968. For a comparison with other meats during the last two decades, per capita consumption of beef, retail weight, increased 27 pounds and prices increased 17¢ per pound; per capita consumption of pork declined 5 pounds while prices increased 12¢ per pound; and chicken consumption increased 18 pounds with a decline in price of 18¢ per pound.

People with higher incomes spend more money for meat. On the average, for each 10% of higher income, the amount spent for beef consumption by city families is 2.8% higher, for pork 1.3%, for lamb 7.8%, and veal 2.8%. This favorable income elasticity pertaining to lamb is one that could be capitalized on--yet the experience in the market place shows little if any benefit from it. A recent nation-wide survey on meat consumption showed that beef was named by 97 percent of all homemakers interviewed as being served more often than once a month. The percentage of homemakers serving other meats at a frequency of more than once a month were: chicken 83%; fresh pork 61%; smoked or cured pork 37%; and lamb 10%. Among factors cited as influencing these choices were: ease of preparation, cost, use for special guests, warm weather meals, different ways of cooking, and ease of digestion. The most common complaint of homemakers focused on packaging--specifically on not being able to see the amount of waste--fat or bone--in a package. Also, the survey revealed that many consumers do not understand the function of inspection and grading of meat. When the responses to two sets of questions were combined, nearly half the consumer replies were either partially or totally incorrect concerning the functions of inspection and grading. This raised a serious question as to whether consumers are really that uninformed, and if so, whether consumer educational activities are lacking, or whether the grades are too complicated. Most persons can understand the order of rank 1, 2, 3, or A, B, C, but they have difficulty understanding "Prime", "Choice", or "Good", and the relationship between these terms and "Inspected for Wholesomeness". Additional consumer research might shed some light on this situation.

C. A Chronology of Selected Activities to Improve the Sheep Industry

At its first meeting in 1947 the USDA Wool Research and Marketing Advisory Committee stated that "A research program will be useful only if there is a domestic producing industry to which it may be applied." It recommended that the Department of Agriculture make a study to determine (1) how large a sheep and wool industry is needed, (2) what policies need to be established, (3) what legislation is required and (4) what improvements can be made within the industry.

In 1950, the above questions were discussed in a USDA report, "Domestic Wool Requirements and Sources of Supply." At the time of this study rayon use for fibers was almost twice that of wool but had replaced little if any wool. Total consumption of fibers had increased. Other man-made fibers had not become serious competitors and the memory of military needs for wool during World War II were still fresh in mind. In this report it was suggested that a national sheep flock of 37 million head would economically utilize the feed and forage resources especially suited to sheep and the resulting shorn and pulled wool production would be about 335 million pounds. Under the Agricultural Act of 1949, the price support for wool at a level from 60 to 90 percent of parity was mandatory. The Act further provided that the level of support be such as to encourage production of 360 million pounds of shorn wool annually.

In 1953, a report to the President from the Secretary of Agriculture stated . . ."Despite our efforts to encourage sheep and wool production through both the tariff and loan and purchase programs for wool, sheep and wool production have remained relatively unattractive compared with alternative farm and ranch enterprises."

In 1954, the National Wool Act was passed which provided incentive payments for wool production and included provisions for a self-help program. See "Trends in Marketing," page 6 . Also the USDA developed a blueprint for research in wool marketing.

In 1955, the American Sheep Producers Council was organized under Section 708 of the National Wool Act. Its purpose was to give sheep producers a working program for expanding the demand for lamb and wool. It was funded through a deduction from incentive payments.

In 1955 and 1956, the Sheep and Wool Research and Marketing Advisory Committee recommended additional educational emphasis on preparation and marketing of wool.

In 1957, the Western States' Extension directors set up a steering committee to explore the possibility of a Western Regional Meeting.

In 1958, the Western Regional Conference on Wool Preparation and Marketing was held in Bozeman, Montana.

In 1959, the wool processing laboratory as part of the Western Utilization Research and Development Division at Albany, California, began operations. For a number of years the Sheep and Wool Research and Marketing Advisory Committee had recommended research that this laboratory would be able to do.

In 1960, the First National Lamb and Wool Industry Conference was held at Laramie, Wyoming. The purpose was to enlarge on the 1958 conference by having much wider representation from all segments of the industry.

In 1961, the Second National Lamb and Wool Industry Conference was held at Laramie, Wyoming, with one of its major objectives to seek solutions to specific marketing problems of lamb. The Industry-wide Lamb and Wool Committee of 30 persons representing various segments of the industry was appointed by the President of the National Wool Growers Association. The American Sheep Producers Council engaged McKinsey and Company, Inc., management consultants, to make a study of the industry in which their stated objective was "to develop recommendations for strengthening the domestic sheep industry. Recognizing that returns to the producer have fallen to an unsatisfactory level, the Council requested an overall review of the industry's present position, an evaluation of its probable competitive position in the future and an appraisal of the more effective ways for improving the industry's position, both in lamb and wool."

In 1962, the McKinsey Report was submitted. Among a number of important recommendations was one calling for unified leadership and direction of the industry. Also emphasis was placed on the need for more effective research. A permanent professional research advisor or coordinator was recommended along with creation of a research foundation.

In 1964, the Industry-Wide Committees for Lamb and Wool presented programs for a "Consumer Preferred Lamb," see "Trends in Marketing," page 6, and "Improving the Preparation of the Domestic Wool Clip." The National Meat Animal Research Center was established at Clay Center, Nebraska, with 25% of its program devoted to sheep.

In 1967, the Sheep Industry Development Program was established to gather, evaluate and compile all available research and information pertaining to sheep and put the information into usable form. This effort has been a goal of the sheep industry for many years. Two State university staff members were engaged for a two year period--one for production and one for marketing research

In 1968, the task force preparing this report was established.

In 1969, a recommendation was made to the President of the United States that a task force be established within the Executive Branch of the Government for coordinating the programs of the different departments of Government. Included would be the Departments of: State, Interior, Agriculture, Commerce, Labor, and Justice. The activities to be coordinated would pertain to: imports, range problems and predatory animals, research, wool manufacturing, immigration and availability of sheepherders and minimum wage. It was recommended that a systems approach be used for dealing with these problems.

D. Research Perspective and Comments

The preceding review of the sheep industry including historical, geographical, technological, and economic aspects should offer guidance in planning future research programs.

After centuries of existence as a pastoral industry the rapidly accelerating technological developments of the 20th Century have created many new problems for the sheep industry. The national concern about these problems was expressed in the Wool Act of 1954. This was followed by other developments including the establishment of the American Sheep Producers Council in 1955, the national conferences, the McKinsey study, the programs dealing with consumer preferred lamb and preparation of wool for market, the updating of both lamb and wool grades, and most recently the establishment of the Sheep Industry Development Program. All of these activities represent steps taken to improve the lot of the sheep industry.

In capsule form this review tells us: (1) There is considerable un-used potential within the sheep industry that provides encouragement for the future; (2) "Feed-back" information from consumers furnishes guides for needed research; (3) Expanded opportunities are developing for interdisciplinary research with improved coordination.

1. Industry Potential.--First of all, we are not dealing with products that are produced in surplus. The US has been a deficit country for lamb and wool for many years. Secondly, we have resources available in terms of land and roughage that would not be used except for production of sheep. Sheep and lambs are natural consumers of roughage, yet thousands of tons of roughage go to waste each year that could be turned into meat and wool. Increased sheep production would increase the utilization of surplus feed supplies.

Promotional programs of the American Sheep Producers Council have shown that sales of lamb can be increased. One of the problems is the lack of availability. It is estimated that if lamb were readily available to all who would like it, per capita consumption for the entire country would double. In addition more people would try lamb and become steady consumers, if it were widely available. If per capita consumption doubled, the requirements for the increased population size in 1980 would be 1.8 billion pounds or over three times the current production. Lamb meat consumption could increase without any reduction in consumption of other meats because there is ample room for increased consumption of meat in this country. A number of other countries consume considerably more meat per capita than the U. S.

Research has shown that more efficient production of sheep is feasible but the follow-up research that would lead to adoption of improved methods has not been adequate. Specifically, there is considerable potential for greater annual productivity per ewe from higher reproductive rates and from reduced lamb losses. Likewise, research has shown many possibilities for reduced feed costs and significant advances have been made. Opportunities for greater gains through further research exist. Research already completed provides the basis for genetic improvement of sheep for efficiency of both lamb and wool production. More research is needed to implement and perfect selection programs; to guide the introduction and use of exotic breeds; to develop more useful crossbreeding systems; and to chart future improvement beyond the limits of present knowledge.

The modern systems approach to management problems of sheep production has almost unlimited potential. This approach needs to be applied to both extremes of sheep production: the intensive system; and extensive system for range areas.

Sheep have potential in areas of unfavorable environments such as the hot, humid areas of the southeastern US where forage can be produced abundantly. Procedures need to be found to permit economical production in spite of high temperatures and the prevalence of parasites. Research to develop breeds with the ability to produce well under these conditions is needed.

Much of the decline in sheep production and in turn lamb consumption has been due to the failure of sheep to compete with alternative farm enterprises. Disease problems, predators, parasites and high labor requirements have all served as important reasons for going out of sheep production and also have been deterrents to new producers. Sufficient research to solve these problems has not been available.

2. Guidance Provided by Consumer "Feed-Back".--The ultimate goal of all commercial agricultural production is the satisfaction of consumers. We have observed that consumers have not always been satisfied with lamb and wool.

Many consumers are interested in adding variety to their family menu of meats. Lamb offers an ideal answer to this desire, however, at times and in certain markets lamb has not always been available. Also, consumers have not always had a pleasant experience because of the quality of the product. We know from previous research that lamb gets its characteristic flavor from the fat. Additional research may provide ways of enhancing or modifying the taste of lamb to increase its acceptance by consumers. The isolation and identification of flavor components may make it possible to alter the flavor through processing or may provide the kind of information that will enable breeders to develop strains of sheep that have more desirable meat flavor.

Many consumers have indicated a "high-price" image for lamb. Historically, there was a basis for this image as lamb prices were consistently above cattle prices before 1958, but since then have been below cattle prices. Also, consumers may have been comparing cuts of lamb with less than comparable cuts of other meat. Factors other than price influence consumption of meat. Under "Trends in Consumption" we noted some very divergent consumption trends for different meats. These changed consumption patterns have substantially influenced the demand for different meats. Such phenomena offer opportunities for additional research.

With respect to wool, in spite of intense competition from manmade fibers wool still has a number of superior qualities according to consumer opinions. Consumers want easy-care, shrink-proof, wrinkle resistant garments. Research to date has contributed a great deal toward these ends and prospects are good that future research can go much further. Basic research has been very useful in making possible the progress thus far and we can expect still more advances as we learn more about the chemical and physical characteristics of wool. Much more investigation of using wool with other fibers needs to be done.

3. More Effective Research Programs.--The task force recognizes the merit of the close association which has existed between USDA and SAES workers and recommends that this relationship be continued as the research program expands.

A very encouraging recent development is the emphasis to be given to sheep and wool research at the newly established U.S. Meat Animal Research Center, located near Clay Center, Nebraska. Plans call for maintaining 10,000 ewes, annually when the research program is fully developed. Of the 67 scientists and more than 200 support personnel to be located at the Center, approximately 25 percent will be engaged in both basic and applied research programs with sheep. The long-range objective is to increase the efficiency of production of consumer-preferred lamb. The planned research effort will include an interdisciplinary approach involving personnel concerned with animal science, engineering, and market quality.

4. Present Research Effort and Recommendations for the Future.--The 1966 inventory of agricultural research shown in Table 1, on the following page indicates that 205 scientist-man-years were devoted to research pertaining to the sheep industry. Sixty-three percent of the research was conducted by the State Agricultural Experiment Stations and 37% by the United States Department of Agriculture. Forty-seven of the continental United States reported some research activity for sheep and wool in the 1966 inventory. Effort ranged from 0.2 SMY in New Jersey to 10.3 in California. The Western States had 51 SMY's; the North Central 35; the South 31; and the Northeast 12. The task force recommends increasing the total effort to 320 SMY's by 1977 as outlined in the next section of the report.

In summary, improvement in efficiency of production and marketing of lamb and wool depends to a great extent on research to provide the knowledge and methods of application which lead to more efficient practices. It is obvious that gains must be made in reducing labor costs, increasing protection from predators, disease and parasites, increasing reproductive efficiency, reducing feed costs, reducing losses from environmental stresses, improving the genetic merit of breeding stock, developing better management practices, improving the quality and usefulness of lamb meat and wool to the consumer and in developing more effective marketing and economic practices.

The sheep industry and the Federal Extension Service have moved to take full advantage of information already available. Researchers in both State and Federal experiment stations have intensified efforts to solve the most critical problems. Shifts in research emphasis are being made constantly to attempt to increase research progress in problems which may be most limiting to increased efficiency. Many opportunities are cited later in this report for making improvements in production of lamb and wool. Likewise, the experiences of the processor-distributor discussed under "Trends in Processing" indicate some new approaches to processing and distributing lamb. Research will be needed to investigate and evaluate these new ideas and activities.

Finally, it is recommended that the total research program be kept flexible so that projections made in this report can be adjusted through future planning and budgeting when new developments occur, or to adjust for projections made in this report that later appear too modest.

TABLE 1. Summary of Inventory and Recommended SMY's for Sheep and Wool

TABLE 1. Summary of Inventory and Recommended SMY's for Sheep and Wool

Research Problem Area	1966 1/			1977 2/			Total Sheep and Other Animals 3/	
	SAES	USDA	TOTAL	SAES	USDA	TOTAL	JC	TF
210 -- Control of Insects	1	3	4	2	3	5	9	10
211 -- Control of Diseases	20	4	24	38	4	42	83	83
212 -- Control of Internal Parasites	12	9	21	20	15	35	42	45
213 -- Protection from Hazards (Predators)	2	4	6	4(6)	5	9(11)	14	16
Subtotal - Protection	35	20	55	64(66)	27	91(93)	148	154
310 -- Reproductive Performance	17	2	19	22	5(10)	27(32)	39	46
311 -- Feed Efficiency	50	2	52	53	3	56	76	73
312 -- Environmental Stress	6	1	7	10(8)	2(6)	12(14)	17	20
313 -- Improved Management Systems	7	3	10	10	6(12)	16(22)	18	26
409 -- Improved Consumer Acceptance	6	3	9	12	6(8)	18(20)	25	27
Subtotal - Production	86	11	97	107(105)	22(39)	129(144)	175	192
410 -- New and Improved Food Products	1	2	3	3(4)	7(6)	10	17	17
411 -- New and Improved Nonfood Products	1	39	40	(1)	49(48)	49	49	49
412 -- Quality Maintenance	1	2	3	2	4	6	6	6
Subtotal - Utilization & Quality	3	43	46	5(7)	60(58)	65	72	72
501 -- Grades and Standards	1	1	2	1(4)	2(4)	3(8)	3	8
505 -- Market Efficiency	4	1	5	5(6)	2(4)	7(10)	8	10
Subtotal - Marketing	5	2	7	6(10)	4(8)	10(18)	11	18
GRAND TOTAL	129	76	205	182(188)	113(132)	295(320)	406	436

1/ Inventory of Agricultural Research, Volume I, Table I, June 1967.

2/ A joint committee representing the Experiment Station Committee on Organization and Policy, and the USDA made combined projections of SMY's for "Sheep and Other Animals," for 1977. The Task Force divided the projections into categories for "sheep" as shown in Table 1 above, and "other animals in Table 2, page 76. In making allocations between SAES and USDA the pattern or proportion used in the original projection by the joint committee was followed to the extent possible without using fractional numbers. The SMY's recommended by the Task Force are shown in parentheses if the recommendation differed from that of the joint committee.

3/ Total of SMY's shown in Table 2 and this Table as projected by the joint committee (JC) and the task force (TF). See also comments in the Preface, page vi.

II RESEARCH GOALS AND PROBLEM AREAS

A. Protection of Livestock - Goal II

In the "National Program of Research for Agriculture," the objective under Goal II is to protect forests, crops, and livestock from natural and artificial hazards. With reference to livestock the program would involve seeking basic information on insects, diseases, parasites, predators, and environmental hazards that cause losses in livestock and developing effective economic means for their control or elimination.

This objective was broken down further into 14 research problem areas of which four were applicable to the sheep industry. These four are: RPA 210, Control of Insect Pests; RPA 211, Control of Diseases; RPA 212, Control of Internal Parasites; and RPA 213, Protection from Toxic Chemicals, Poisonous Plants, and Other Hazards.

Estimates of losses to the sheep industry in the U. S. from diseases annually amount to $15 million; from parasites $45 million; and from predators more than a million head of sheep, thus the problem of protection is most important. The causes of a number of diseases are still unknown. The lack of accurate, rapid diagnostic techniques for identifying diseases often permits them to get a substantial start in a band or flock before measures can be taken to bring them under control. Disorders caused by parasites are ubiquitous, generally insidious and often overlooked entirely. Diagnosis is difficult, and successful treatment often not available. The threat of foreign diseases getting into the US hangs over the industry constantly as increased world travel magnifies the possibility of infection here.

CONTROL OF INSECT AND OTHER ARTHROPOD PESTS OF SHEEP

RPA 210

Situation: The biology of several of the external parasites of sheep is incompletely known and this lack of knowledge seriously hinders development of satisfactory control measures.

Although insecticide controls have been developed for lice, mites, ticks, flies, and fleas affecting sheep, in many instances tolerance to the insecticides, residues in meat, toxicity to the animals, and unsatisfactory application methods invalidates their use for the intended purpose. Insects and ticks are common intermediate hosts or mechanical transmission agents of diseases and parasites, e.g., bluetongue of sheep and, as such, constitute a serious potential hazard in areas where the diseases and parasites are endemic.

Objective: To control or eliminate insects, ticks, and other pests that have a detrimental effect on the health and economics of raising sheep.

Research Approaches:

A. Identify pest species and determine their complete life histories and their environmental needs.

B. With the above information available, test chemical and nonchemical insecticidal agents against the various forms of the pest species in those situations that appear to provide the best opportunity to disrupt the cycle or discourage damage. Evaluation studies of promising toxicants can be accomplished on small flocks or even individual animals by applying sprays, dusts, or dips or by feeding systemics.

C. Standard and new techniques of insect control through manipulation of the environment, bacteriological agents, or other biological control measures should be emphasized.

D. Economic evaluations of damage by the pest species, various transmitted diseases or parasites, and costs associated with control are vital to all proposals and should be undertaken by agricultural economists to establish the economic feasibility of various control methods.

Potential Benefits: Control of the parasites and the diseases they transmit would result in a healthier, more productive animal. Lower production costs would result and higher quality wool and lamb could be marketed.

Research Effort:	Inventory 1966	TF Recommendation 1977
SAES	1	2
USDA	3	3
TOTAL	4	5

CONTROL OF DISEASES OF SHEEP

RPA 211

Situation: Infectious diseases cause significant losses to the sheep industry. These encompass primarily the diseases caused by specific bacterial or viral agents. Vibriosis, listeriosis, bluetongue, salmonellosis, caseous lymphadenitis, paratuberculosis, pasteurellosis, the clostridial infections, contagious ecthyma, lip-and-leg ulceration, and enzootic abortion are examples of such diseases. Although many methods have been developed and are utilized for the diagnosis, control, prevention, and treatment of these diseases, losses from disease continue to make inroads to profitable sheep production. In general, the losses from disease are of two types--those resulting from reduced production efficiency caused by loss of flesh from illness and resultant prolonged feeding to reach market quality or those resulting from outright death of the affected sheep. Many opportunities exist for the development of improved and more rapid methods of diagnosis of the infectious diseases and for their prevention or control.

Respiratory disease remains one of the major problems of the sheep industry. The pathogenic agents of parainfluenza-3 and the pleuropneumonia-like organisms (PPLO) and psittacosis-lympho-granuloma-venereum (PLV) groups plus bacteria have been isolated from lungs of diseased sheep. Of these agents, only para-influenzia-3 is classified as a true virus; the PPLO and PLV are intermediate in size and have some biochemical properties of both viruses and bacteria. One or more of these infectious agents plus Pasteurella bacteria can produce pneumonia in more than 50 percent of susceptible lambs when challenged. (The lung-worm, Dictyocaulis filaria, is common in some areas and also contributes to pneumonia, especially in lambs in their first summer of life.)

In recent years there has been increasing interest and concern about the influence that epididymitis and orchitis play on the fertility of the ram. A number of different bacteria have been recovered from cases of epididymitis and orchitis. Principal among these is Brucella ovis, the ram epididymitis organism (REO). The complement-fixation test seems to be the best method of detecting REO. However, this test is not routinely run at most diagnostic laboratories because of its complexity.

Mastitis of range ewes is primarily caused by Pasteurella mastitidis. It is one of the most important diseases of range ewes in the western states. In this type of mastitis, gangrene develops quite rapidly thus giving origin to the common name "blue bag." Death occurs in about 25 percent of the ewes so affected. In range bands the incidence of mastitis probably averages around 2 percent.

Listeriosis is widely prevalent in sheep producing areas. Its cause is the bacterium Listeria monocytogenes. Many of the serious outbreaks of encephalitis ("circling disease") occur within 3 or 4 weeks after feeding silage from a newly opened silo. Average losses from listeric encephalitis in areas where the disease is prevalent are from 2 to 4 percent but in some outbreaks may reach 10 percent or more.

Contagious foot rot is a major problem in many sheep-producing areas of the United States. Sheep seldom can be grown economically if the flock has foot rot. This infectious disease destroys the tissues that connect the horny cover of the sheep's hoof with the soft underlying tissues, causing the outer horn to separate from the hoof. Sheep of all ages and all breeds are susceptible.

The risk of the importation of foreign animal diseases has greatly increased in recent years by the arrival of over 350,000 aircraft and approximately 202 million passengers per year from foreign ports. Many of these arrivals originate from areas where at least one disease foreign to U. S. livestock is present. To prevent such diseases from getting a foothold and becoming widespread in the U.S. livestock population, rapid and accurate diagnoses are mandatory for their identification and the application of sound and appropriate control measures. Foreign sheep diseases of concern are foot-and-mouth disease, scrapie, sheep pox, goat pleuropneumonia, louping ill, Nairobi sheep disease, contagious agalactia and Borna disease.

Objective: Develop improved methods for the diagnosis, control, prevention, and treatment of infectious diseases of sheep.

Research Approaches:

A. Develop simplified methods for distinguishing immunogenic variation in causative agents for diseases such as vibriosis, salmonellosis, and bluetongue.

B. Define more specifically the causative factors responsible for the common respiratory diseases of sheep and identify the role that each plays in the pathogenesis of the disease.

C. Develop techniques for more rapid and simplified methods of diagnosis of sheep diseases, such as ram epididymitis.

D. Improve the antigenicity and the antigenic spectrum of immunizing materials for sheep diseases, such as vibriosis and bluetongue.

E. Identify more specifically the reservoirs of infection which give rise to new epizootics of diseases, such as epizootic abortion, vibriosis, bluetongue and pneumonia.

F. Develop practical procedures for controlling or eradicating selected diseases, such as vibriosis, listeriosis, salmonellosis, caseous lymphadenitis, ram epididymitis, foot rot, mastitis, and epizootic abortion form infected premises.

G. Develop and improve diagnostic procedures and other methods for keeping foreign sheep diseases out of this country.

Potential Benefits:

1. Increased production efficiency.

2. Increased percentage of sheep born that would reach market or productive age.

Research Effort:	Inventory 1966	TF Recommendation 1977
SAES	20	38
USDA	4	4
TOTAL	24	42

CONTROL OF INTERNAL PARASITES OF SHEEP

RPA 212

Situation: Internal parasites, such as the nematodes (roundworms) flukes, tapeworms, and coccidia cause losses in all regions of the United States and in all seasons. Severe parasitism may cause heavy direct losses to the livestock producer, but internal parasites generally are unseen, their effects usually are not apparent, and the loss to the public from inefficient production is hidden. Major losses include mortality, reduced yield, condemnation of meat, feed wastage, and cost of drugs. Problems from parasitism increase with intensified sheep production practices. Parasitism, after a time, is usually a limiting factor to profitable intensified production. Even for the parasites that have been the subject of considerable research, treatment or control measures are far from adequate.

Objective: Find new and improved chemicals for combating parasitisms and seek biological methods and management practices that will minimize or circumvent reliance on chemicals.

Research Approaches:

A. Test chemical materials of promising value against the various helminth species for effectiveness in eliminating or disrupting development of specific stages of the parasite life cycle.

B. Search for the arthropod intermediate hosts of the fringed tapeworms.

C. Develop methods to exploit the immunity that develops to certain parasitisms and investigate possibilities of genetic resistance to parasites in certain strains of sheep for parasite control.

E. Investigate possible biological control of internal parasites through infectious agents, predators, and parasites.

D. Seek methods to replace virulent populations of parasites with strains of parasites of modified pathogenicity--biological control by population replacement.

Potential Benefits: More effective methods for the control of internal parasitisms would increase the productive efficiency of the sheep industry and increase the net farm returns to sheep producers. Control of tapeworms and liverflukes would reduce the large number of livers that are now condemned annually.

Research Effort:	Inventory 1966	TF Recommendation 1977
SAES	12	20
USDA	9	15
TOTAL	21	35

PROTECTION FROM HAZARDS

RPA 213-A

Situation: Sheep growers in the western United States lost 1,100,000 sheep and lambs in 1966 to predators. There are no known figures for losses in the midwest and eastern states. In addition to this, large expenditures of time and money are made to treat and care for injured animals. Trapping, destroying, and hunting dogs and coyotes is very costly and has not been completely effective. Present methods of controlling these predators have often made enemies for the sheep industry. Wildlife protection groups, sportsman groups and dog owners object to present methods of predator control. Rather than treat injured animals, which is very discouraging, and to chance the loss of friends, many small growers have abandoned the industry while economic losses have forced many large producers to turn to alternate types of livestock production.

Objective: Develop a predator repellent or other humane control methods, which can be economically utilized by sheep growers.

Research Approaches:

A. Evaluate dog repellents already developed by the U. S. Postal Service and the horticulture industry for possible use as a predator repellent for sheep.

B. Study new products that may be objectionable to dogs and coyotes.

C. Study behavior of dogs and coyotes to determine most effective repellants and attractants or other control methods.

Potential Benefits: Elimination of the predator loss to the sheep industry. The possible saving of over a million sheep and lambs annually and an increase of sheep numbers in areas where sheep cannot be grown now.

Research Effort:	Inventory 1966	TF Recommendation 1977
SAES	2	6
USDA	4	5
TOTAL	6	11

NOTE: The above allocation includes RPA 213-B.

PROTECT SHEEP FROM TOXIC CHEMICALS, POISONOUS PLANTS, AND OTHER HAZARDS

RPA 213-B

Situation: The continuing development of insecticides, chemosterilants, herbicides, and numerous other chemicals for widespread use in improved control of livestock and plant pests requires increased study of their harmful effects upon sheep. Information will be needed concerning their residues or other harmful effects on the quality of meat and fiber.

Poisonous plants have caused extensive losses to the livestock industry since the days of the early settlers and are still a significant economic problem in the sheep-producing areas of the west. A considerable amount of information on many toxic plants has been accumulated over the years and the practical application of this knowledge has helped livestock owners reduce losses to a considerable extent. The information on many of these plants is still incomplete.

Objective: To reduce or eliminate hazards in sheep production.

Research Approaches:

A. Investigate the acute and chronic toxic effects of insecticides, chemosterilants, herbicides, and other agricultural chemicals on cellular processes, such as enzymes, on interferences with reproduction, such as teratogenicity and other systemic disturbances of sheep.

B. Determine the toxic elements and pathological effects on livestock of selected known and suspected poisonous plants, such as lupines, locoweeds, oxalate-producing plants, and others.

C. Expose sheep to measured amounts of a chemical to be studied to determine the toxicological, pathological, and physiological effects. Chemicals to be studied should be selected on the basis of their usage and the urgency of the need for information about them.

D. Conduct studies to determine the toxicological and pathological effects of poisonous plants on sheep in general and more specifically to determine the toxic and lethal doses of specific plants at various stages of growth. Include studies on the variations in toxicity of identical species of plants from various areas, in different years, and on different types of soil. Study the chemical components of plants which bring about specific effects such as fetal malformation.

Potential Benefits: Development of safer pesticides and ways to prevent livestock losses from poisonous plants. Identification of the potential or real toxicity of a given plant and evaluation of environmental factors affecting levels of toxicity and control will afford more extensive utilization of range areas for sheep. Man will be the benefactor through improved health and increased livestock and crop production brought about through better control of hazards.

NOTE: Research effort included under RPA 213-A.

B. Efficient Production of Livestock - Goal III

In the "National Program of Research for Agriculture" the objective under Goal III is the production of an adequate supply of farm and forest products at decreasing real production costs. Within this objective the research effort would be aimed at (1) developing new strains of plants and animals with the potential for higher economic returns; (2) the development of optimum plant and animal nutrition as well as cultural and management practices; and (3) the selection of enterprises and the kinds, amounts, and combinations of inputs (such as labor, land, breeding stocks, seed, fertilizers, machinery) that will give maximum efficiency in farm and forest enterprises.

The objective was further broken down into 16 research problem areas of which four were applicable to the sheep industry; RPA 310, Reproductive Performance; RPA 311, Feed Efficiency; RPA 312, Environmental Stress; and RPA 313, Improved Management Systems.

In the introduction, under research perspective it was pointed out that the ultimate goal of production was the satisfaction of consumers. A major step in the direction of producing the kind of lamb and wool desired by consumers was achieved when the sheep industry developed specifications for consumer preferred lamb and procedures for improving the domestic wool clip. The price of lamb is related to the price of other meats. Competition helps maintain a certain relationship based on purchases made by consumers. Improvements in efficiency of production will enhance lamb's performance in the market place. Likewise, it will strengthen lamb's position in competition with imports which are produced where costs are much lower than in the United States.

Improvement in efficiency of production depends to a great extent on research to provide the knowledge and methods of application which lead to more efficient practices. Gains need to be made in reducing labor costs, increasing reproductive efficiency, reducing feed costs, reducing losses from environmental stresses, improving the genetic merit of breeding stock, developing better management practices, and producing the kind of raw material that will end up in products most acceptable to consumers. In addition to needing the best information available about what to produce, sheepmen need to know how best to produce it. The following statements are directed at this broad problem.

IMPROVED REPRODUCTIVE EFFICIENCY IN SHEEP

RPA 310

Situation: Maintenance and expansion of the sheep industry rests on improvement in reproductive efficiency. Lambs produced per ewe have a high relationship to economic efficiency. Failure to increase lambs per ewe in the 1960's over that attained in the latter half of the 1950's may have contributed to the decline in sheep numbers.

Currently 93 lambs are saved of 100 ewes on hand. This represents some increase over past years with an average of 82, 86, 93, and 94 for the succeeding decades from the 1930's. However, in the latter half of the 1950's the average was 96 with the peak record of 98 in 1958. Thus progress since the late 1950's is lacking. There is need for increases in lamb production per ewe per year.

There is tremendous potential for increased numbers of lambs from each ewe each year. Litters of up to 8 lambs have been produced and 4 lambs per birth are feasible. Furthermore it has been shown that it is possible for ewes to produce lambs in consecutive six month periods. More realistically for the near future a 50% increase in lamb production seems possible and a 300% increase can be envisioned. However, further research is needed to bring even the lower increase to fruition and adoption.

Increased lamb production may be limited by late puberty, restriction of the breeding season, postpartum or lactation anestrus, failure to show estrus, low ovulation rate or failure of ovulation, low fertility of the male, failure of sperm transporation in the ewe, poor conception, failure of implantation, embryonic death, abortion, stillbirth and early postnatal death. The solution to each of these problems may require a different research approach. The tendency of the ewe to be a seasonal breeder and the sensitivity of reproductive processes to ambient temperature contributes to many of these problems.

More complete knowledge of the reproductive processes is essential in improving reproduction efficiency. Reproductive capacity as well as all aspects of reproduction must be more adequately measured in each sex. The factors which affect reproductive capacity must be identified and their relative importance should be determined. The interrelationships of the various phases of reproduction with important genetic and environmental influences must be known much more completely. Circulating hormones affecting reproduction need to be identified and measured at all stages of reproduction. Behavior as it affects reproduction should be studied in depth.

A better understanding of the reproductive processes will aid progress in other research problem areas. Nutritional efficiency is closely related to reproductive efficiency. Environmental stress is an important cause of

lowered reproductive efficiency. Many management practices are designed to increase or facilitate high reproductive rates. Breeding methods through selection, crossbreeding, choice of breed or use of exotic breeds offer effective means of increasing the reproductive rate.

New concepts in reproduction of sheep should be possible with accumulating basic knowledge and parallel applied research. Each phase of the reproductive process should be brought under control either through use of hormone or partial environmental control. Twice yearly lambing through use of hormones should become a practical reality. Methods of superovulation and storage and transfer of ova should become practical. Successful long term storage of ram semen for artifical insemination should also become practical. Sex control should also be possible and would permit some operators to specialize in producing replacement females.

Objective: To improve reproductive efficiency of sheep.

Research Approaches:

A. Use basic research to obtain a more complete knowledge of the reproductive processes.

B. Develop procedures to increase and control litter size.

C. Develop methods to reduce the age of puberty and the interval between lambings to permit maximum numbers of lambings per year.

D. Develop physiological and genetic ways of removing seasonal restrictions on reproduction.

E. Perfect methods of estrus synchronization and develop means of correcting low fertility associated with it.

F. Determine the interrelationships of the various phases of reproduction with important genetic and environmental influences and particularly try to alleviate reproductive inefficiency due to high environmental temperatures.

G. Develop means of reducing prenatal, natal and early postnatal death losses.

H. Develop adequate measures of reproductive capacity, identify the factors which affect it, and determine their relative importance.

I. Study behavior as it affects reproduction and determine means for reducing behavioral limitations.

J. Measure all circulating hormones affecting reproduction at each stage of reproduction to provide a comprehensive basis for control of reproduction.

K. Develop ways of improving male fertility.

L. Develop methods of freezing and storing ram semen without loss of fertilizing capacity.

M. Develop practical methods of ova storage and transfer.

N. Develop methods of sex control.

Potential Benefits: The greatest benefit from improving reproduction will result from an increase in the total efficiency of the industry. Many of the costs of overhead and of maintaining breeding animals are much the same regardless of the number of lambs produced per ewe. Increases in lamb production should come from increasing the number of lambs rather than the number of ewes with a resulting increase in efficiency. Increases in the proportion of ewes lambing, the number of fertile rams, the number of lambs marketed per lambing and the increase in frequency of lambing where this is practical should bring returns greater than the added costs. Larger selection differentials will occur from higher lambing rates, artifical insemination, and ova storage and transfer. Sex control will permit greater specialization in meat production through increased production of males for slaughter and females for replacement. Also, it will permit large selection differentials for traits revealed in only one sex.

Control of reproduction should lead to a more even supply of lamb over the year and to increased supplies during the periods of greatest demand.

Maintenance of ewes in a reproductive state for a greater portion of the year will reduce feed costs relative to production. Lambing facilities would be more fully utilized. Furthermore, the control of reproduction would allow the adaptation of sheep production to a much wider range of climatic and feed conditions. Control of reproduction will be essential to the most effective use of intensive production systems.

Research Effort:	Inventory 1966	TF Recommendation 1977
SAES	17	22
USDA	2	10
TOTAL	19	32

IMPROVED FEED EFFICIENCY IN THE PRODUCTION OF LAMB AND WOOL

RPA 311

Situation: Sheep compete less for foods which humans can eat directly and consume less concentrate feed than any other red-meat producing animal. When data are adjusted for wool removed at slaughter, sheep and lambs use only 87% as much concentrate as beef cattle and 36% as much as swine to produce a pound of dressed carcass. Total harvested feed used to produce a pound of dressed sheep and lamb carcass is essentially the same as that needed to produce a pound of beef carcass.

Fifty-eight percent of the total agricultural land in the United States is classified as grazing land. Food production from this land requires the use of grazing animals. Sheep can and do utilize this land more effectively than other grazing animals. Research has shown that total livestock production per acre may be higher when sheep and cattle are grazed together than when grazed separately. A proper balance of the two species is therefore desirable.

Research with pelleted feeds for sheep has shown that wide fluctuations in the ratio of concentrates to roughage can be used without major effect on the efficiency of feed used or rate of gain. Therefore, sheep feeding practices can be rapidly adjusted according to the supply of grain and forage excess to other needs. The same degree of flexibility does not exist with other animals especially nonruminants. Basic research has indicated that new sources of cellulose, such as hemicellulose from wood, might be used as a source of feed stuff. Nonprotein sources of nitrogen can be used by sheep. Further basic research indicates that volatile fatty acids might be used as sources of energy for sheep. Further research should extend the range of materials, not suited for use by simple-stomach animals, that can be used for production of human food through sheep.

The overall efficiency of conversion of pounds of feed to pounds of sheep and lamb is quite low, ranging from 7 to 12 pounds of feed per pound of sheep and lamb produced. Other estimates indicate that sheep require 13.5 feed units (feed value of one pound of corn or its equivalent) per pound of output. Pounds of feed required to produce a pound of lamb have been as low as three for young lambs under an intensive management system, and less than five pounds of feed per pound of gain have been reported under various conditions.

Increasing the feed efficiency of sheep and lambs, however, is not just a matter of using the latest feed and management techniques since feed efficiency ranged from 4.4 to 8.5 pound of feed per pound of gain when lambs were fed the same feed, in the same manner, and to the same final weight in a recent trial. At the present time we cannot predict feed efficiency of a sheep or groups of sheep without use of feeding trials.

Carcass composition also varies widely among lambs under the same management and feeding regime. For example, in a recent trial, percentage of fat in whole dressed carcasses varied from 22 to 37% when lambs were slaughtered at a constant weight. A low-fat-to-lean ratio is desirable from the consumer standpoint as well as for feed efficiency since lean tissue is produced at a lower energy cost than fat.

Feed represents the greatest part of the cost of production of lamb and wool. Approximately 60% of the feed cost is used for ewe and ram maintenance and 40% for lamb feed.

Objective: To reduce the amount and cost of feed required to produce a unit of lamb, mutton or wool and at the same time improve the quality of the products to the consumer.

Research Approaches:

A. Reduce the amount of feed required to maintain sheep and produce a unit of lamb and wool through improved nutrition and biochemistry.

B. Develop new and improved procedures and biochemical tests for evaluation of feed efficiency.

C. Determine the hormonal and nutritional relationships for optimum production.

D. Determine the biochemical and physiological mechanism which control feed intake of sheep.

E. Increase the availability and utilization of nutrients from feedstuffs.

F. Select high efficiency animals by biochemical tests and use selective breeding for increased feed efficiency.

G. Develop nutritional procedures to make possible the greater use of byproducts and nonfeedstuffs.

H. Reduce feed costs by altering carcass composition of lambs so as to produce more lean and less fat.

I. Determine optimum feeding regimes for each phase of maintenance, reproduction, and growth under different levels of production.

J. Develop suitable diets for an accelerated lambing program including requirements for both ewe and lamb with early weaning.

K. Study effects of environmental extremes on feed utilization.

Potential Benefits: Increased lamb meat production at lower unit cost should increase the supply of lamb meat at a more competitive price. The industry can be extended to new areas and can utilize vast quantities of byproducts, waste materials and feeds unfit for human consumption. More desirable lamb meat can be produced at lower cost.

Reductions in costs of feeding stock sheep by 25% and of feeding lambs by 40% would appear to be attainable. This would result in an overall reduction of about 31% in the cost of sheep production.

Research Effort:	Inventory 1966	TF Recommendation 1977
SAES	50	53
USDA	2	3
TOTAL	52	56

ENVIRONMENTAL STRESS IN SHEEP PRODUCTION

RPA 312

Situation: Unfavorable environmental conditions are a major cause of low productivity of sheep. Extremes of temperature although well tolerated by sheep may bring about lowered reproductive rates or increased losses. High temperatures are particularly damaging to both ram and ewe fertility and may reduce feed intake and slow growth rates. Extremely high temperatures may also result in death losses. Sheep in full fleece are well protected against low temperatures but are largely defenseless immediately after shearing. Heavy losses may follow cold wet storms soon after shearing. Sheep do not thrive under damp humid conditions.

About 22% of the stock sheep in the United States are found in the eight South Central States plus South Carolina, Georgia and Florida. Much of this area produces abundant forage which could be utilized by sheep. The percentages of lambs produced per ewe in these States were 78 and 84% in 1967 and 1968 as compared with 105 and 106% in the 12 North Central States. Much of the reduced productivity of sheep in the South is caused by effects of heat and humidity and these factors also have harmful effects over much of the country. Feed intake and gains of growing lambs are adversely affected by hot humid weather. An increase of 2°F in body temperature of ewes will result in failure of the embryo to implant and a lesser increase may cause death of the embryo. Ambient temperatures of 90°F or above, with moderate humidity is sufficient to increase body temperature of most breeds and strains. High temperatures during pregnancy reduce birth weights and increase lamb mortality. High temperatures also reduce ram fertility. Acute heat prostration of lambs may occur when hot weather is combined with high humidity. Improved adaptability to unfavorable climatic conditions without loss in productivity is needed. Furthermore, ways must be developed for practical alleviation of environmental stresses.

Very little is known concerning optimum environmental conditions with newer intensive production practices such as early weaning, confinement rearing, out of season breeding and lambing induction of estrus and ovulation with hormones, and more frequent lambing. Sheep producers must intensify and use less labor and put more capital investment in housing and equipment to remain competitive and to survive. With these changing conditions there is dire need for research on the interrelationship of environmental factors with growth and reproduction.

Objectives:

A. To increase adaptability of sheep to various environmental stresses.

B. To determine optimum environmental conditions for sheep under various systems of production.

C. To determine housing and equipment needs for provision of optimum environment for intensive production.

D. To determine interrelationships of environment, production practices, growth and reproduction.

Research Approaches:

A. Improve adaptability of domestic breeds of sheep to withstand environmental stress.

B. Develop new strains of sheep with high productivity under unfavorable environments.

C. Evaluate the effects of various environmental factors such as temperature, humidity, light, space and type of housing and equipment on sheep performance.

D. Identify important genetic-environmental interactions influencing lamb and wool production.

E. Establish optimum environmental requirements and develop economical ways to provide such conditions, particularly for newer, more intensive systems of production.

F. Develop effective means of alleviating environmental stress and to aid sheep in adjusting to specific conditions.

Potential Benefits: Gains in this problem area would permit the establishment of a more successful sheep industry in the South and particularly the Southeast which would allow more effective utilization of the capacity to produce forage and would also increase farm income. This would aid in maintaining a desirable rural-urban balance in the South and in other warm, humid areas. Increased supplies of lamb could be made more available to southern consumers to whom lamb is now largely unavailable. Higher quality lamb at lower cost would be made available. This research would add to the basic fund of knowledge regarding mechanism by which high temperatures affect fetal development and other aspects of reproduction and also the relationships between metabolism and temperature stress.

Research Effort:	Inventory 1966	TF Recommendation 1977
SAES	6	8
USDA	1	6
TOTAL	7	14

IMPROVED SHEEP BREEDING SYSTEMS

RPA 313A

Situation: Sheep have a high potential for increased production. More rapid and efficient lamb gains, greater reproductive rates and more pounds of high quality lamb and wool per ewe are readily attainable and would increase the efficiency of production. It is anticipated that lamb consumption would at least triple if a plentiful supply were available to all consumers at a reasonable price. Sheep, because of their small size, low cost of investment, dual products and also because of their ability to use waste roughages, are well adapted for small farms as a supplemental source of income. They lend themselves well as a means of relieving rural poverty. They represent a ready potential for production of high quality protein for people in developing countries.

There is no evidence of improvement in lamb or wool production since the mid or late 1950's. Number of lambs saved per 100 ewes of breeding age was about 87 in the 1920's and 95 in the mid 1950's. A peak of 98 was reached in 1958 but the current level is 94. Rate of gain has improved somewhat in the past 50 years but this no doubt has been due as much to improved management and nutrition as to breeding. Pounds of lamb marketed per ewe appears to have increased but much of this is due to marketing at heavier weights. Fleece weights average about 8.5 pounds, but there is no indication of an upward trend since 1955.

Improved selection aids, techniques and breeding systems can greatly aid in increasing the efficiency of sheep production as genetic gains are permanent and accumulative. Tremendous genetic gains in number of lambs weaned per year and the weight of individual lambs weaned as well as improved rate of gain and quality are possible. Although genetic gains come slowly, a steady improvement in genetic potential is feasible and seems basic to other means of increasing efficiency of production. Much of the failure to make gains in the recent past seems due to failure to apply the knowledge available. Therefore, research to implement and to determine how to apply the principles of genetic improvement, such as a national sheep improvement plan, is urgent.

Recent research indicates that twinning can be improved more rapidly by selection than was formerly thought possible. Most fleece characteristics are thought to be highly heritable and thus can be improved rapidly with effective selection. Little information is available on the inheritance of carcass traits in lambs. Very little has been done in the way of breed comparisons either as to their merit in different geographical areas of the United States, or for their crossing ability for the production of hybrid lambs.

Research is needed to develop a strain or strains of sheep capable of lambing more than once per year and at any time of the year. Breeding research is also needed to develop strains or types of sheep resistant to parasites and diseases. Many breeds exist outside the United States which might be useful purebreds, in crossbreeding, in improving existing breeds for specific traits and in developing new breeds for special uses or adaptations. Exotic breeds should be imported and used in research to determine how they can best be used in improving domestic sheep production.

More effective selection methods are needed to permit more rapid improvements in productivity without increased costs. Genetic parameters continually change and vary for different breeds under different conditions. More complete and precise knowledge of these parameters would lead to more efficient breeding procedures and greater genetic progress. Means of detecting recessive gene defects in heterozygotes or more efficient tests for carriers would aid in the elimination of defects. More adequate measures are needed for many traits such as carcass merit in the live animal to permit effective selection for improvement.

Performance recording and testing is now used by a small minority of breeders. A recent survey showed that active performance testing programs are underway in 14 states and considerable efforts are being made in 8 additional states. In most cases on-farm testing is used. Records are obtained on both lamb and wool production and environmental factors are considered. The majority considers both individual and progeny records. Carcasses are evaluated in six states. Six states have central test stations. Somewhat under 300 purebred flocks are testing involving about 1,000 rams and 10,000 ewes out of an estimated 400,000 purebred ewes and over 200,000 purebred rams. In addition, 143 commercial flocks have almost 68,000 ewes involved in testing. It is estimated that there are over 5 million commercial ewes which are unregistered or high grade but predominately of a particular breed. Thus while good performance testing programs are available in many states the participation is so low that they can have little impact on the improvement of the entire sheep population. A National Sheep Improvement Plan is needed to implement a uniform and effective procedure for all sheep breeders.

An increase in the number of lambs marketed per ewe per year is so basic to increasing efficiency of production that all important approaches must be investigated simultaneously. Favorable approaches have been described under RPA 310 on reproductive efficiency, RPA 311 on feed efficiency, and RPA 312 on environmental stresses but a number of alternative approaches available through breeding will provide gains to which advances in these other areas will be additive.

Objective: To develop selection aids, techniques, breeding systems and practices to increase the total pounds of lamb and pounds of wool produced per ewe per year.

Research Approaches:

A. Establish a national sheep improvement plan to implement performance recording and more effective selection practices into a high proportion of the sheep breeding flocks of the nation.

B. Develop more effective selection practices for the improvement of efficiency of lamb and wool production.

C. Make more effective use of domestic breeds through comprehensive evaluations and comparisons of all traits which may be economic under present or anticipated future production methods.

D. Make more effective use of crossbreeding through accumulation of information on the expected gains from various breed combinations under different environmental conditions.

E. Introduce all promising exotic breeds and test them for their usefulness as purebreds, in crossbreeding, in improving existing domestic breeds for specific traits and in developing new breeds for special uses or adaptations.

F. Develop more useful breeding systems. Such are possible but are not available now because of our limited knowledge of the genetics of the sheep. Systems of mating, genetic environmental interactions, means of increasing genetic variation, and artificial manipulation of germ cells and chromatin material are examples of the investigations needed.

Potential Benefits: Genetic improvement of sheep would improve almost all aspects of efficiency of production. Most important would be a reduction in unit costs through lowered costs for feed and care and an accompanying increase in unit production through more pounds of high quality lamb and wool produced per ewe. These alone could restore the sheep industry to a profitable situation. There would be the additional benefits of a more plentiful supply of lamb and wool at lower cost to the consumer.

Research Effort:*	Inventory 1966	TF Recommendation 1977
SAES	7	10
USDA	3	12
Total	10	22

*Total for areas 313A, 313B and 313C.

IMPROVED SHEEP PRODUCTION MANAGEMENT SYSTEMS

RPA 313-B

Situation: Sheep numbers have declined in recent years despite the fact that returns on investment are higher from sheep than with some other classes of livestock. The decline in sheep numbers has generally been attributed to management problems such as difficulty of obtaining suitable labor, control of dogs and other predators, control of internal parasites, control of foot rot and to the specialized knowledge required to handle sheep successfully. Requirements for labor during the lambing season is high and and often inefficiently used due to irregularities in time and rate of lambing. Experienced sheep shearers are scarce in many areas and sheep shearing is very arduous for inexperienced personnel.

More efficient production systems are urgently needed for sheep. Production costs have increased, and mechanization has been difficult to apply and slow to come by. None-the-less, there is an increasing amount of new technology becoming available and being applied and innovative engineering and management practices are being tested and adopted. As a result, established systems of sheep production are being modified and new systems are being developed. Manufacturers have generally not had strong incentive to produce specialized equipment for sheep because of the small and declining size of the industry. However, availability of specialized equipment, particularly of a labor-saving type, might lead to expansion of the industry. The development of chemical shearing shows how research can lead to labor-saving methods and reduce the need for skilled labor.

In many parts of the country, sheep are kept in small uneconomical units which do not receive specialized attention and which employ no labor-saving devices. Possibilities for profit could be increased if more efficient sized units were intensified and managed as major sources of income rather than as secondary or supplemental enterprises. Thus, people are in need of objective information which they can use in making decisions relative to modifying established systems and developing new systems of sheep production. Systems for the future must be worked out to embrace in varying degrees the control of reproduction and multiple lambing, artifical rearing, early weaning and confinement.

An economic analysis of modified and new systems of sheep production is needed not only for decisions in production but also in regard to marketing, slaughtering, processing and distribution. Such information is essential for objective decision making in geographical areas where the production systems are being modified and developed but also in each of the other production areas of the country.

Objective: To develop modified and new sheep management systems and economic analysis of these systems which (1) maximize yield of lamb meat and wool from a minimum input of land, labor, feed and equipment and (2) can

be organized into economically viable production units. Particular emphasis should be given to those situations where new technology is being applied and innovative engineering and management practices are being tested and adopted.

Research Approaches:

A. Determine production unit size to best fit feed supply, markets, varying inputs of labor and profit potential for different areas.

B. Develop management systems to reduce the unit requirement of labor, equipment, facilities, feed and land for most efficient production.

C. Develop systems research to lower feed requirements, control disease and parasites through preventive medicine, lowering labor requirements through mechanization, and use of low-cost buildings to increase profitability of sheep production.

D. Maximize returns per acre through coordinated use of crops, pastures and sheep management systems.

E. Reduce manhours of labor required by developing labor-saving methods and equipment.

F. Develop mathematical models for simulating various production systems to identify limiting factors and problems requiring attention.

G. Develop management systems to increase productivity per ewe, per unit of labor and per acre of land.

Potential Benefits: Increased profitability of sheep production, expansion of the sheep industry, increased supplies of lamb and wool at reasonable prices and more complete and efficient utilization of the nation's agricultural resources.

Research Efforts: See RPA 313-A.

IMPROVED SHEEP WASTE DISPOSAL AND MANAGEMENT SYSTEMS

RPA 313-C

Situation: Present trends toward increased specialization and intensification of the sheep industry, especially with greater use of confinement and of lamb feed, will lead to greater problems of waste disposal and pollution. However, under intensive systems, odors from sheep may be less of a problem than with other classes of livestock. The odors which occur are probably from simple compounds such as ammonia and hydrogen sulfide. Sheep feces have the highest proportion of dry matter of any of the livestock species. Drying as a means of use or disposal should be more economical than with other species.

Ways need to be developed to prevent pollution and health or esthetic problems from sheep operations before such problems become serious.

Objective: To develop efficient and effective methods of sheep waste disposal to prevent pollution of air, soil or water and to avoid health or esthetic problems.

Research Approaches:

A. Develop efficient methods of management of sheep wastes from barns, feedlots and other production units.

B. Develop economical methods to utilize waste products from sheep.

Potential Benefits: Increased profitability of sheep enterprises, reduced costs of waste disposal, and improved human environment are all potential benefits.

Research Effort: See RPA 313-A.

IMPROVED CONSUMER ACCEPTANCE OF LAMB AND MUTTON

RPA 409-A

Situation: Surveys of consumer attitudes about lamb and mutton indicate that the major problem in consumer acceptance is the inconsistency of flavor. The high frequency of undesirable odors and flavors in sheep meat has drastically influenced the confidence consumers have in their purchases of this meat. Basic flavor research can ultimately lead to the production of a uniform and desirable flavor and the greater acceptance of lamb and mutton as a food. Preliminary studies have indicated that the palatability of lamb fat can be improved through breeding and control of environmental factors. The growth curve of lambs of different types and breeds as it relates to deposition of fat and muscle tissues is not well understood and neither are the effects of nutrition, genetic and management factors that affect the deposition of muscle and fat tissue. Adequate procedures are not available for differentiation between fat and muscle tissues in the live animal. Thus, tools are not available to implement production programs aimed at improving the production of consumer preferred lamb. For this reason, it has not been possible for the industry to develop effective production programs to improve carcass merit in lambs even though the industry has long been cognizant of this problem. A major research effort will be required to make a significant breakthrough that will be of assistance to the sheep industry and consumer.

Objective: To improve consumer acceptance of lamb and mutton.

Research Approaches:

A. Develop and evaluate useful measurements to determine fat covering and meatiness in the live lamb.

B. Further investigate and identify the components of flavor in adipose and muscle tissue of lamb and mutton.

C. Determine the relative importance of each flavor component in establishing desirable and undesirable flavor and odors.

D. Relate the important flavor components to inheritance and the environmental factors associated with sheep production.

E. Determine the possibility for production of 120- to 140-pound lambs that would be acceptable to the consumer.

F. Reduce the fat content in lamb carcasses to a minimum level necessary for market handling and consumer acceptance.

G. Increase the proportion of the more valuable cuts and increase the size of the loin eye muscle.

Potential Benefits: Make available to the consumer more uniformly acceptable lamb and mutton. Through greater acceptability of the meat, reversal of recent trends toward lower per capita consumption of lamb and mutton would result, along with economic benefit to producers.

Research Effort:	Inventory 1966	TF Recommendation 1977
SAES	6	12
USDA	3	8
TOTAL	9	20

NOTE: The above effort includes RPA 409-B.

IMPROVED MILL AND CONSUMER ACCEPTANCE OF WOOL

RPA 409-B

Situation: Wool represents an important source of income to sheep producers as a joint product with meat. It has superior qualities over synthetic fibers for many purposes and is often used in blends to give desirable properties to the end product. Improvement in wool quality would improve its competitive position with other fibers and its desirability by consumers. Limited progress has been made in developing methods for measuring quality factors such as strength, handle, color, crimp, scratchiness, resilience, feltability, contamination, and clean yield. It is known that each quality trait of wool is influenced by breeding, feeding, and management. A more complete understanding of the effects of these factors and their interactions would contribute toward the production of improved wool.

Objective: To produce wool that is more acceptable to consumers.

Research Approaches:

A. Develop methods and procedures for increasing the length and strength of fibers and crimps per inch, and decrease the variability among fibers.

B. Develop methods for decreasing the occurrence of black fibers and improving color in the direction of whiteness.

C. Develop methods for increasing clean yields of wool.

D. Develop wool with improved handling qualities and resilience.

Potential Benefits: Improved quality of wool produced would add to the desirability of wool products by consumers and improve the competitive position of wool with other fibers.

NOTE: For research effort see RPA 409-A.

C. Product Development and Quality - Goal IV

In the "National Program of Research for Agriculture," under Goal IV, the objective is to expand the demand for farm and forest products by developing new and improved products and processes and enhancing product quality. Within this objective the research effort would be aimed at:

1. Developing strains of livestock having attributes that meet preferences and desires of consumers;

2. Improvement of production practices, processing methods and marketing procedures so as to preserve or enhance inherent qualities of farm products;

3. Development of new and improved products from agricultural commodities; and

4. Expand markets by tailoring products to meet customer preferences and by increasing product utility for the consumer.

The objective is further broken down into 12 research problem areas of which three will be discussed in this section: RPA 410, New and Improved Food Products; RPA 411, New and Improved Products From Wool, Hides, Skins, and Animal Fats; and RPA 412, Quality Maintenance in Marketing Lamb. RPA 409, pertaining to production of lamb and wool with improved consumer acceptability is discussed in the preceding section. As mentioned in the "Preface," a statement pertaining to Goal IX is included in this section. It pertains to pollution and waste products from wool processing plants. The scientist-man-year effort is in addition to those shown in the Summary Table, page 17.

NEW AND IMPROVED FOOD PRODUCTS FROM LAMB

RPA 410-A

Situation: Lamb is currently available to retailers primarily in carcass form, especially in communities other than our major metropolitan areas. The meat retailer in smaller communities is often faced with a problem of procurement and with the problem of selling the less desirable lamb cuts. Additionally, the availability of lamb in carcass form is very seasonable, thus many consumers can not regularly purchase lamb at reasonable prices that are competitive with other meat products. Consumer acceptance of many cuts of lamb is influenced by their composition and quality. The amount of bone and the relative proportion of muscle and fat are major objections in the purchase of the less desired cuts. Tenderness in these cuts may be less than acceptable, especially if the method of cookery is incorrect.

Objective: To develop forms of fresh, frozen and processed lamb products of optimum quality and leanness which will be acceptable to consumers in the amounts required on a regular basis at prices they are willing to pay.

Research Approaches:

A. Develop boneless forms of fresh and frozen lamb products that can be widely distributed without losses in quality.

B. Determine size and shape of cuts most acceptable and size and composition of carcasses necessary to provide these cuts.

C. Determine the desirable size and composition of carcasses best adapted to the requirements established in B.

D. Develop processed forms of products from the less desirable cuts of lamb, which would have adequate consumer acceptance. Blends of these boneless meats with other protein materials should be explored.

Potential Benefits: Make lamb more generally available to consumers through the development of new and more convenient forms, and improve the palatability of less desirable portions of lamb carcasses.

Research Effort:	Inventory 1966	TF Recommendation 1977
SAES	1	4
USDA	2	6
TOTAL	3	10

NOTE: The above effort includes RPA 410-B.

NEW AND IMPROVED PRODUCTS FROM MUTTON

RPA 410-B

Situation: Mutton constitutes about one-sixth of the total meat derived from the US sheep industry but commands a price of only 27% of that for lamb. Mutton may sometimes be undesirable in terms of tenderness, texture and flavor and is not well accepted as a fresh product. Mutton is used largely in soup stocks, sausages and other prepared meats. Further increases in usefulness of mutton in processed meat may be feasible. Further development of speciality products from mutton should enhance its acceptance by consumers.

Mutton is generally produced from sheep which are kept for breeding and are later culled. The low price of sheep for mutton serves as a deterrent to culling and tends to restrict progress from selection. Many carcasses are condemned for diseased conditions. This contributes to the low price for mutton. Many acceptable mutton carcasses are of high quality and are highly palatable. This is especially true of sheep of yearling or relatively young age. Methods of measurement are needed so that the highly desirable mutton may be distinguished from that which is less desirable before it reaches the retail market. The less desirable products could be used entirely in processed form.

Objective: To develop specialty and other processed products from mutton meat which will have palatability characteristics acceptable to consumers, and increase the value of slaughter ewes.

Research Approaches:

A. Investigate the possibility of extracting proteins from low grade mutton carcasses, and reconstituting these proteins into products more acceptable to consumers.

B. Investigate the possibility of blending either extracted proteins or the unextracted proteins with other protein materials into uniform, desirably flavored and textured products.

C. Through processing techniques, manipulate flavors in order to provide new products with greater consumer appeal.

Potential Benefit: Provide desirable products for consumers at relatively low cost in relation to the nutritional value.

NOTE: For research effort see RPA 410-A.

IMPROVED WOOL AND MOHAIR YARNS

RPA 411-A

Situation: Woolen system processing research is important to the well being of our domestic industry because half of the wool consumed domestically is processed on the woolen system. The woolen system consumes two-thirds of the coarser grades of wool and the major portion of lamb's wool, the types grown in greatest quantities in the United States. The woolen system is simpler and less expensive than the worsted system, but at present it is adapted chiefly to making heavier weight fabrics whereas modern trends are towards lighter weight fabrics. With the growing consumer demand for lighter weight apparel having ease-of-care performance, there is a need to find ways to adapt the lower cost woolen manufacturing system, for the production of uniform, lighter weight yarns and also yarns that more closely resemble the worsted types. Also with the trend in textile manufacture towards reducing the number of processing steps, using higher speed machinery, and otherwise simplifying processing, it is necessary that wool and mohair be adapted to these processing changes. These goals appear possible through opportunities now opened by chemical modification of these fibers. In order to take the best possible advantage of utilization research on wool and mohair, steps have been initiated to incorporate woolen system processing research along with research on the worsted system now available.

Objective: To develop efficiently produced superior yarns made on the woolen system that will increase the demand for wool and mohair in light-weight woven and knit fabrics.

Research Approaches:

A. Evaluate woolen carding and spinning characteristics of wool fibers modified by selected chemical and physical treatments.

B. Evaluate the contribution to spinnability and yarn characteristics of selected mixtures of natural and modified wool and mohair.

C. Develop for commercial use optimum treatments of wool and mohair and fiber mixtures of these for woolen system processing of yarns with desired functional properties.

Potential Benefits: Wool and mohair yarns with greater uniformity, attractiveness, stability and performance features; wider range in yarn types; lower costs in transforming wool and mohair into yarns; substantially increase market outlets for wool and mohair by virtue of added quality values.

Research Effort:	Inventory 1966	TF Recommendation 1977
SAES	1	1
USDA	39	48
TOTAL	40	49

NOTE: The above SMY allocation includes 411-B, -C, -D, and -E.

TREATMENTS FOR WOOL AND MOHAIR PRODUCTS TO REDUCE UPKEEP COSTS

RPA 411-B

Situation: Many of wool's competitors advertise a degree of permanent press performance that requires no ironing. This can not yet be equalled in all-wool fabrics. New and better treatments of wool and mohair are needed that will enable these fibers to meet the desires and requirements of modern consumers. Although excellent shrink resistance is provided by the WURLAN process, this process requires 2 treating baths, an important disadvantage. Preliminary basic research now indicates the possibility of developing a single bath, aqueous emulsion that not only can give superior shrinkproofing of wool and mohair but also may provide no-iron performance. and it is possible that research can develop treatments that provide additional features, such as superior resistance to soiling, wrinkling and abrasion.

Objective: To develop economical multipurpose treatments of wool and mohair that will provide important features desired by the modern consumer of textiles.

Research Approaches:

A. Develop polymer emulsions which will react with wool and mohair to give shrink-resistance without stiffening the fabric or otherwise damaging fiber mechanical properties or fabric aesthetics.

B. Investigate the reactions of newly available chemicals with wool and mohair to give improved dimensional stability and wrinkle and greater abrasion resistance.

C. Investigate new methods for promoting desirable modifications of wool, such as application of radiofrequency and high energy radiation.

D. Develop, from the new information on treating chemicals and techniques, durable superior finishes which provide economical multipurpose benefits, including dimensional stability, wrinkle resistance, greater abrasion resistance, durable protection of wool fabrics against oil and water borne soils, and improved soil-release in laundering.

Potential Benefits: Reduce the costs of chemical finishing of wool and mohair fabrics and provide the consumer with superior products with lower upkeep costs.

NOTE: Research effort included under RPA 411-A.

IMPROVED PROCESSING OF WORSTED WOOL AND MOHAIR

RPA 411-C

Situation: Worsted yarns enjoy a market usually somewhat greater than that of woolens, the ratio dependent on fluctuations due to style changes. Worsted yarns are characteristically fine, smooth and sleek. Fabrics made from these yarns are used widely in suitings, jerseys and double-knits. Modern mass production textile manufacture places high premium on uniformity of raw materials, on predictability and repeatability of their processing behavior, on adaptability of the fiber assemblies to higher speeds of production with minimum equipment stoppages because of faults, and finally on uniformity of quality of products. The introduction of higher speed machinery has focused special need for research to adapt wool and mohair to enable most efficient use of this equipment. Wool and mohair are inherently irregular in qualities, and partly because of this worsted processing is time-consuming and costly, involving a great number of operations from the raw fiber to the spun yarn. Opportunities have been opened for imparting new desired properties to wool and mohair and for improving the efficiency and reducing costs of making wool and mohair worsted products that have improved uniformity, suitability and attractiveness.

Objective: To substantially reduce the present costs of drawing, spinning, weaving and knitting of worsted wool and mohair fabrics.

Research Approaches:

A. Ascertain optimum conditions for chemical and physical modification of surface and internal properties of wool and mohair fibers to produce enhanced mechanical processing behavior.

B. Ascertain the degree of mechanical crimping along with setting of wool and mohair fibers needed to provide improved mechanical processability.

C. Determine the possible and necessary modifications of present mechanical processing equipment that will give optimum performance and quality production.

D. Develop the promising physical, chemical and mechanical research findings for commercial application.

Potential Benefits: Reduction in costs of transforming wool and mohair into worsted yarns and fabrics, greater variety of worsted yarns of uniform high quality, greater appeal of wool and mohair to textile manufacturers as a result of the better control on fiber qualities and the greater predictability and repeatability of processing behavior.

NOTE: Research effort included under RPA 411-A.

NONWOVEN WOOL AND MOHAIR FABRICS

RPA 411-D

Situation: Continued and significant advances are being made in the production of nonwoven fabrics from fibers other than wool. The manufacture of wool felt, which strictly speaking is nonwoven fabrication, has not kept pace with modern technology. Of all textile fibers, wool has the most outstanding ability to form felt. This superiority of wool in nonwoven materials should be exploited along with application of modern processing techniques and appropriate chemical treatments in order to make new desirable nonwoven fabrics from mohair as well as from wool.

Objective: To develop nonwoven wool and mohair fabrics with new textures and superior properties for apparel and nonapparel uses.

Research Approaches:

A. Investigate and develop, where feasible, new mechanical processing techniques and new fabric structures to produce strong, yet soft nonwoven apparel fabrics, taking advantage of the ability of wool and mohair fibers to felt.

B. Ascertain the effects of resins and grafting or crosslinking of polymers for bonding wool and mohair fiber arrays and develop the best treatments to produce an aesthetically attractive nonwoven fabric retaining the characteristic handle and appearance of wool and mohair.

Potential Benefits: Lower cost of manufacture of wool fabrics and expanded markets for wool through development of new products.

NOTE: Research effort included under RPA 411-A.

NEW CONSUMER-DESIRED WOOL AND MOHAIR BLEND PRODUCTS

RPA 411-E

Situation: The blending of fibers provides opportunities for achieving properties not possible in fabrics made from a single kind of fiber. Much more wool and mohair could be utilized than has been in the past through judicious blending, especially by using appropriately modified wools and mohair. For example, a modest effort has already brought research results which indicate a wide new market for wool and mohair durable press blends. Further improvements of these products are needed and many new consumer-desired products are possible, for example less scratchy products from wool and mohair.

Objective: To seek new and wider range of desired aesthetics and improved wear properties possible through blending of chemically modified wools and mohair with other fibers.

Research Approaches:

A. Determine the performance characteristics of knit and woven, woolen and worsted fabrics made of a range of mixtures of selectively modified wools and mohair with appropriate cotton and manmade fibers.

B. Optimize for commercial application the best treatments and and blend levels for specific end use performance and aesthetic properties.

Potential Benefits: Increased wool and mohair utilization through wider range of blends of desired aesthetics and performance.

NOTE: Research effort included under RPA 411-A.

QUALITY MAINTENANCE IN MARKETING LAMB

RPA 412

Situation: Lamb is primarily sold as a fresh unfrozen product. The sale of lamb in carcass form seriously restricts its availability to consumers. If lamb is to be distributed widely and if it is to be made available on a regular basis, the industry will need to seriously consider the sale of prefabricated fresh and frozen products. The maintenance of acceptable color, a uniform desirable flavor and acceptable texture in frozen products is not satisfactory with existing methods.

Objective: To develop environmental conditions and packaging for the control of desirable color, flavor and texture during the interval that lamb is stored fresh or frozen prior to and during distribution.

Research Approaches:

A. Determine optimum temperature and relative humidity for storing and distributing fresh lamb with various packaging materials.

B. Determine conditions for storing and distributing frozen lamb.

C. Investigate packaging materials in relation to color retention and flavor stability of fresh and frozen lamb.

Potential Benefits: Improve the demand for lamb by providing a regular supply of uniform quality that is acceptable to consumers.

Research Effort:	Inventory 1966	TF Recommendation 1977
SAES	1	2
USDA	2	4
TOTAL	3	6

POLLUTION AND WASTE PRODUCTS FROM WOOL PROCESSING

RPA 901

Situation: The growing problem of pollution is jeopardizing our domestic wool processing industry. The pollution of streams by liquors resulting from wool processing, including scouring wastes and spent dye liquors was a major reason for the wool industry's move from New England to the South. And now that pollution has become a problem of great national concern it is necessary and urgent to solve this problem. Associated with this situation is the recovery of large quantities of waste, including unrecovered lanolin as well as wool fiber too short for textile purposes. Such wastes present problems in 2 ways--how to get rid of them and how to reduce the economic loss due to loss in weight of wool. To turn the waste into profitable use would greatly benefit the wool textile industry.

Objective: To develop effective methods of turning the wastes of wool processing into useful products as well as minimizing pollution of streams by spent liquors of processing.

Research Approaches:

A. Evaluate and develop, if feasible, wool waste, unsuitable for textile purposes, for other possible uses, such as a source of protein.

B. Investigate possible new useful products made from the chemical constituents of suint and wool grease, and develop where feasible for commercial application.

C. Investigate and develop means of treating wool processing liquors with possible recovery of water used.

D. Investigate and develop solvent processing methods for chemical finishing and dyeing to reduce volume of waste processing liquors.

Potential Benefits: Elimination of the pollution of streams caused by waste liquors of processing, along with reduction in costs of processing wool by more complete utilization of raw materials.

Research Effort:

	TF Recommendation	
	1972	1977
SMY's	5	4

NOTE: The above SMY's are not included in the Summary Table page 17. Animal and domestic wastes and processing wastes are discussed in a separate task force report entitled "Environmental Quality - Pollution in Relation to Agriculture and Forestry."

D. Efficiency in Marketing Sheep and Wool - Goal V

In the "National Program of Research for Agriculture," Goal V, "Efficiency in the Marketing System," contains the following objectives: (1) to provide farmers with better market guides for making production and marketing decisions; (2) improved quality and availability of production items and services; (3) facilitate distribution of products; (4) improve the quality and availability of products to the consuming public; and (5) reduce the resources required in the transfer of products from farm to consumer.

These objectives were broken down further into ten research problem areas of which two were assigned to this task force. They are RPA 501, Improvement of Grades and Standards; and RPA 505, Physical and Economic Efficiency in Marketing Livestock. The other RPA's, 506 through 510 pertain to supply, demand, and price analysis; competition; domestic market development; marketing firm and system efficiency; and farmer bargaining power. These problem areas pertain to the entire agricultural marketing system of which sheep and wool marketing are a part. In using the commodity approach for this report, the factors affecting marketing under RPA's 506-10 will be dealt with in RPA 505 as they pertain to the marketing of sheep and wool.

Under the previous sections on "protection" and "production" we have been concerned about factors largely under the control of the producer. In the section on "product development and quality" we were concerned about changing the physical form of the product by processors. In this section we are concerned about the activities that take place between the producer and consumer which involve change in ownership and in providing the consumer with the desired kind of product at a time, place, and in the kind of package or container which will satisfy him. The customer may be a country assembler of raw material (live animals or wool), processor, warehouseman, wholesaler, retailer, or final consumer. In most transactions between buyer and seller the negotiation has three important elements--quantity, quality, and price. The quantity is usually determined by generally accepted units of measure. For describing quality, it is very helpful if there is a common market language such as standards and grades. The price, usually determined by the quantity and quality, serves as a common denominator in most marketing transactions. This may seem elementary, but a clear understanding of the many activities and forces that are reflected in the prices of products as they flow through our modern complex marketing system will help in planning research programs dealing with these activities and forces.

Most of the physical activities such as assembling, processing, storing, transporting, and distributing are visible and can be measured in terms of output per unit of input. Research on these factors is relatively easy. There are other invisible forces that affect price such as competition, market information, and consumer attitudes that cannot be measured except through their effect on firms, transactions, and product sales. Competition may cause firms to go out of business; market information may provide buyers or sellers an opportunity to take advantage of certain situations; and

consumer attitudes can determine whether a product succeeds or fails in the market. Research on these factors is much more complicated than on the physical factors. The better we understand these physical factors and economic forces that interact within the marketing system the better chance there is of having an ideal marketing system.

We do not have an ideal marketing system and the one we have is in a constant state of change. If we had an ideal marketing system, buyers and sellers would have complete knowledge about all the factors affecting their transactions; consumers would be provided exactly what they want; the product quality would be measured by objective methods and described in simple terms; there would be competition between many sellers and many buyers so the price would be at an equilibrium level determined by the forces of supply and demand. Producers would know exactly what consumers wanted. Handlers and processors would be able to communicate with each other and with producers and consumers in understandable terminology to describe product attributes; and, prices would reflect value differences of well-defined gradations of quality.

In the statements that follow, a number of specific research problem areas are discussed in terms of the above classification as they affect the sheep industry.

IMPROVEMENT OF GRADES AND STANDARDS

RPA 501

Situation: In buying and selling agricultural products, one of the most uncertain elements is an accurate description of the product characteristics that affect their value to the user. For that reason grades and standards were designed to describe product characteristics. As the marketing system changes because of technological developments in production, processing and distribution, there is need to evaluate grades and standards to be sure they accurately describe the products being bought and sold.

Like most everything else in nature, meat is a heterogeneous product. It varies greatly according to age, finish and shape or conformation. Grading is a process of sorting a heterogeneous supply of a commodity into smaller, more uniform or homogeneous groupings or units. These groupings should be economically significant--the quality attributes should be such that a price differential can be established. Present lamb grade standards do not always insure that products will be sorted according to their general acceptability to consumers. Taste tests, whether conducted with a panel of skilled taste testers, or with a family meal may indicate that some meat from a particular grade may score higher than meat from a quality grade above the one being tested. This need not be a reason for condemning grading--rather it emphasizes the state of the art today and points up the need for additional research to refine and improve the procedure. Ideal grade standards would make it possible for every unit within grade to be interchangeable with every other unit, perfectly substitutible.

There are two sets of factors that influence meat quality grades. Visible indicators of quality include physical factors such as finish, marbling, feathering, and age. Invisible attributes include hidden variables that affect consumer acceptability or palatability such as tenderness, juiciness, flavor, and aroma. This latter group is one that offers real challenge to researchers to develop some means of identifying and measuring them. Recent advances in technology and instrumentation offer hope that even such difficult problems as these are not insurmountable.

Wool faces a similar problem. The consensus of most segments of the textile industry is that existing methods and procedures of wool quality evaluation do not provide for measurement of all characteristics significantly affecting its use value, nor a means of reflecting these value differences in prices. The need for improved evaluation of differences in wool's physical and chemical characteristics becomes more urgent as a result of continuing changes in marketing and processing and the more stringent demands of textile manufacturers and consumers. The problem is further intensified by the development of manmade fibers and their continued improvement which enhances their competitive position relative to wool. The incompleteness of current grades and standards for wool undermines the ability of prices to act as effective guides to production and marketing and the optimal selection of wool qualities to meet specific end product requirements (See RPA 505-A).

Objective: To objectively measure differences in all characteristics affecting lamb and wool quality and establish their economic values.

Research Approaches:

A. Identify and measure the relative importance of factors influencing the eating quality of lamb and mutton and develop practical, workable, objective measures of these factors.

B. Development of more adequate quantitative measures of the relationship of variation in wool quality factors and alternative processing techniques to processing performance and cost, quality, and value of end products.

C. Development of fiber test instruments that can be used under commercial conditions to accurately measure differences in all important quality factors.

D. Determine the range of variability in quality attributes within which lamb meat is relatively interchangeable to consumers.

E. Further refine those characteristics in feeder and slaughter animals that indicate carcass potential.

F. Evaluate the effectiveness of existing grade standards in terms of serving the needs of sellers and buyers and for reflecting different gradations of quality which affect value and use.

G. Determine the need for standards and grades for products for which grade standards do not exist.

H. Develop improved descriptive terminology of grade standards which will characterize the different product attributes so as to facilitate communication between sellers and buyers.

Potential Benefits: Effective grades and standards enable buyers to obtain product characteristics desired and sellers to obtain appropriate compensation for what they sell. Accurate description of products should provide more reliable market information to sellers and buyers. Prices should more accurately reflect value differences for varying gradations of quality. Buyers and sellers should be equally well informed so that neither is at a disadvantage in conducting marketing transactions. By eliminating the need to personally inspect products the cost of buying and selling should be reduced.

Research Effort:		Inventory 1966	TF Recommendation 1977
SMY's	SAES	1	4
	USDA	1	4
	TOTAL	2	8

PHYSICAL EFFICIENCY IN MARKETING SHEEP AND WOOL

RPA 505-A

Situation: The concept of physical efficiency as used here refers to the operating procedures used in assembling, processing, packaging, transporting, storing, distributing, and the work methods, equipment, devices, structures, and containers, in marketing sheep and wool and their products.

Many of the livestock and meat marketing, slaughter, and warehouse facilities occupied today are obsolete and the work methods that can be used in such facilities are antiquated. As a consequence, labor costs are excessive and are increasing. Many firms still occupy facilities designed primarily for handling rail receipts and rail shipments even though the majority of these products today are moved by motortruck. This situation also adds to handling costs. Changes in transportation systems, population growth and shifts, and advancements in technology have brought about changes in the types of facilities--such as livestock auction markets, commercial feedlots, hotel supply houses, and specialty meat processing plants. Engineering and related research is needed to design improved plant layouts, to minimize travel distances and excessive handling and the development of work methods that will permit use of mechanized and automated equipment.

Shrinkage, stress, bruising, and death cause heavy losses during handling and transporting of livestock. There are few major areas of economic and industrial management inquiry where solid research results are more limited than in the field of transportation. It is not surprising that physical distribution has been described as the last great frontier of industrial waste and inefficiency. Transportation costs for the entire food and food products industry have been estimated at 17 percent of total net sales. A transportation authority has estimated that no more than 15 percent of the possible economies in physical distribution are now being realized.

Cost of marketing wool and manufacturing wool fabrics account generally for 15 to 20 percent of the consumer dollar spent for wool products compared to about 9 to 13 percent going to sheep producers. Reductions of cost in the marketing-manufacturing area would contribute directly to improving wool's competitive position and possibly increase domestic supplies and decrease imports. Research in this area should include work designed to reduce cost and increase the operating efficiency of individual firms and functions involved in moving wool from farms and ranches through fabric manufacturing plants. In developing this research care must be taken that optimization of one function does not have a deleterious effect on other functions. For example, scouring in the producing area might substantially decrease transportation cost but lower producer incomes and increase processing cost. It is essential therefore that the research be designed to determine the optimum complete production-processing-manufacturing system. Without consideration of the complete system, less than optimum results are likely to occur (See RPA 501).

Objective: To bring about the most effective flow of products from farm to consumer beginning with live animals and wool on the farm and ending up with products in the form, time, place, and quality most desired by consumers.

Research Approaches:

A. Determine the most effective methods, facilities, equipment, and cost-reducing systems for handling, processing, packaging, transporting, and distributing sheep and wool products, including the type, size, and location of facilities.

B. Determine the relationship of firm size, and composition of products to marketing and processing costs.

C. Determine the relationship of equipment design, plant layout, handling methods, storing, and preparing for market on product quality and marketing costs.

D. Develop new or improved equipment for handling, storing, and preparing lamb and wool for sale to improve the quality and reduce marketing costs.

E. Determine the effect of transportation equipment design and performance and methods of transportation on marketing and processing costs, product loss and end product quality.

F. Develop packaging and transportation methods and techniques to maintain product quality and reduce transportation costs.

G. Determine the possibility of reducing wool textile manufacturing cost by providing more adequate quality measures to promote better selection of wools to meet processing and end product requirements.

H. Develop economic-engineering data indicating optimum processing organization for various qualities of wool and types of end products to lower manufacturing cost for wool textiles relative to manmade fibers.

I. Determine the qualities of wool which, when processed with the optimum organization will permit operating at higher speeds with minimum ends down, loom stops, and occurence of seconds.

Potential Benefits: Sheep and wool would be handled in the most advantageous manner at the lowest possible cost. Losses of product and quality deterioration would be minimal. Consumers would receive high quality products at the time, in the form, and at a place desired by them.

Research Effort:		Inventory 1966	TF Recommendation 1977
SMY's	SAES	4	6
	USDA	1	4
	TOTAL	5	10

NOTE: the above SMY allocation includes 505-B, -C, -D, -E, and -F.

COMPETITION AND PRICE DETERMINATION FOR SHEEP AND WOOL

RPA 505-B

Situation: Competition is generally considered a regulator of the economy. Although there are numerous forms of competition, price is a common denominator for expressing it in the market place. When products flow through the marketing system the activities pertaining to physical efficiency discussed under RPA 505-A take place simultaneously with pricing activities. Most of the physical activities such as assembly, processing, storing, transporting, and distributing are visible and can be measured in terms of output per unit of input. Many activities affecting price are not visible except when stated in sales agreement or in terms of price but many unseen factors influence the net result. Pricing effectiveness pertains to how well the pricing mechanism gives coordination and direction to the entire production and marketing sequence. How effective the pricing system is depends to a large extent on how rapidly and accurately prices reflect desired weights, grades, quality and number and how rapidly and accurately producers, processors and others can evaluate and act upon this information.

Competition requires competitors. The number, size, and type of firms and the potential ease of entry of new firms, profoundly affect the competitive environment in which each operates. If effective competition is defined as arriving at prices which reflect actual market supply and demand conditions, it is difficult to determine when this is actually being achieved. In the "old days," livestock arrivals at terminal markets could be counted with a high degree of accuracy but the decentralization of livestock marketing has made it more difficult to determine the supply and demand of livestock on any given day.

There is nothing magic about price determination. Neither buyers nor sellers have perfect market information. This leaves room for possible variations in prices among markets. Added to the problem of efficiency and effectiveness in arriving at equilibrium prices is the associated problem of communicating timely and reliable information about prices. Greater and more accurate product knowledge and market knowledge are needed for this purpose. Pricing and other procedures affecting change of ownership will require increasing evaluation, considering the key importance they play in allocating resources and distributing income in the changing livestock-meat economy.

Objectives: To evaluate the process of price determination for sheep and wool on a continuing basis to provide information for the purpose of maintaining in the marketing system an equilibrium price reflecting the interaction of the forces of supply and demand.

Research Approaches:

A. Evaluate the conditions under which prices are arrived at for each transaction from the first assembly point for live animals and wool to the retail purchase by consumers.

B. Evaluate the effects of integration, formula pricing, specification buying, administered prices, forward pricing, the decline of terminal markets, and other developments that may emerge as part of the marketing system for sheep and wool.

C. Evaluate the competitive situation with respect to number, size, and type of firm and the entry of new firms to determine whether the competition is viable and effective.

D. Evaluate the availability of information pertaining to prices of sheep and wool and the communication process by which it is made available to buyers and sellers so that all may be equally and fully informed.

E. Evaluate the performance of price as a means of guiding production of sheep and wool.

Potential Benefits: It should be possible to develop an effective pricing mechanism that will guide activities in the sheep industry so that optimum resource allocation will result. This should insure an adequate supply meat and wool to meet the demands of consumers and reward producers equitably for a good job of production and penalize those who do a poor job. Research may be able to develop formulas that will provide efficient and equitable treatment in cases where traditional pricing methods become obsolete.

NOTE: The allocation of SMY's is included in the statement pertaining to RPA 505-A.

MARKET STRUCTURE AND OPERATION FOR SHEEP AND WOOL

RPA 505-C

Situation: Not only is our marketing system imperfect, it is very complex. Aspects of its operation involve the efficiency of individual firms; competition among firms; bargaining power of farmers; the role of consumers; and the overall effect of transportation, location of processing, and interregional competition. These components are researchable elements of the marketing system. Also, we can look at marketing as a flow of products from farm to consumer--in which there are "activity stages" or functions such as: (1) assembly and sale of live animals; (2) processing; (3) storing; (4) pricing; (5) market information; and (6) retail distribution.

When we look at the changes in marketing that have occurred since World War II it is obvious that many millions of dollars invested in terminal market facilities in Chicago and other large terminals have been shifted to other markets. This kind of transfer of resources is costly and ultimately comes out of producer returns or from higher prices to consumers or from capital losses on the part of processors or investors. Reliable research information can be useful in guiding resource allocations in the future.

Apropos this situation, the Animal and Animal Products Research Advisory Committee in 1965 and each year since has made the following recommendation:

"Overall Study of Livestock Marketing. The economic structure of the nation's livestock and meat production-marketing complex is in the midst of great change. Livestock marketing and processing facilities are becoming more decentralized during a period when most marketing and processing operations for other agricultural products are becoming more centralized. Large multispecie packing plants, located in major industrial centers, are being replaced by efficient specialized plants located in livestock production areas.

"Very large sums of money are now invested in the present structure of livestock marketing and processing which handles a portion of our food supply equivalent to about half the value of consumer expenditures for food. There has been a great proliferation of packer and processor buying operations, markets, market agencies, and dealers in the assembly of livestock. The great numbers of these, many not providing either adequate or economical service, represent inefficiencies and high cost. Because of the changes occurring in this very important segment of the U. S. economy, all those concerned with it from producer to consumer need information that will guide them in making future decisions.

"A benchmark study is needed that would encompass historical, geographical, technological, and economic developments of the livestock and meat production-marketing complex. This study could provide information on costs and services rendered by the various components of the marketing system which would help explain the influence of various factors that have contributed to the changes. It should be conducted simultaneously throughout the country and encompass all the marketing activities from the producer to consumer."

Objective: To provide information about the historical, geographical, technological, and economic development of the livestock and meat production-marketing complex as a basis for decision making in the future.

Research Approach:

A. Conduct a nationwide study of the livestock and meat production-marketing complex to obtain the information requested in the Advisory Committee recommendation.

Potential Benefits: The sheep and wool marketing system has many small relatively inefficient and high cost operating units. Reliable research information should help to bring about a reduction in the number of such units. Based on experiences of the last quarter century, information leading to better business decisions should save untold millions of dollars in the next quarter century.

NOTE: The allocation of SMY's is included in RPA 505-A.

SUPPLY, DEMAND, AND PRICE ANALYSIS FOR SHEEP AND WOOL

RPA 505-D

Situation: This statement represents the commodity approach to RPA 506. In order for decision-makers in the sheep industry to make sound and accurate judgments a great deal of information is needed about the relationship of the sheep industry to the rest of the economy and the world. Producers, processors, distributors, and consumers need information based on accurate quantitative knowledge of the interrelationships among prices, production and consumption of farm products, and other factors. Similarly, Congress and the administrators of farm programs need such economic information to evaluate existing and alternative programs or policies in terms of their probable impact on production, consumption, and prices at both the farm and retail levels. The typical producer as well as most other entrepreneurs in the sheep industry cannot afford to collect and analyze all the statistical and economic information necessary for making sound production and marketing decisions.

Important shifts have been occurring in the demand for meat and poultry products--to date the shifts have been unfavorable for lamb--however, economic conditions and consumer preferences can change. The decennial household food consumption surveys provide regular benchmarks for analysis of lamb consumption in relation to other meats, fish, and poultry, as well as substitutes.

Objective: To provide a continuous flow of information based on analyses of factors affecting the supply, demand, and price, of sheep and wool upon which entrepreneurs in the sheep industry can make sound decisions.

Research Approaches:

A. Develop a national forecasting model for analyzing production adjustments, and for estimating monthly and quarterly supplies, slaughter, prices and demand.

B. Keep abreast of information available through household food consumption surveys for regular benchmarks and make estimates for interim periods.

C. Evaluate the effect of substitute meats and other meats on the market for lamb.

D. Evaluate the effect of substitute fibers on the market for wool.

E. Evaluate the effect of imports and exports on the sheep industry.

F. Provide long-run projections of economic growth and demand and prices.

G. Evaluate major developments in farming and major changes in national policies and programs.

Potential Benefits: Information on supply, demand, and price analysis along with projections of economic trends and farm income provides the basis for outlook work, policy planning, and farm program appraisal. Such information should bring about more accurate and sound decisions throughout the sheep industry. Producers can vary their production programs, and meat packers can more accurately plan their labor needs and regulate their inventories.

NOTE: The allocation of SMY's is included in RPA 505-A.

CONSUMER ATTITUDES AND PREFERENCES FOR LAMB, MUTTON, AND WOOL

RPA 505-E

Situation: Domestic lamb and wool consumption depends on the behavior of some 200 million consumers. In our complex marketing economy it has become almost impossible for consumers to discuss their preferences, opinions, satisfactions, and dissatisfactions with producers and marketers. Knowledge of consumer reactions is becoming increasingly important--mistakes in developing, producing, and marketing products are costly not only to the farmer but to processors and distributors as well.

An understanding of consumer reactions and the reasons behind them is essential to planning improvements in the production, processing, and marketing of sheep and wool, and for developing educational programs, setting or revising grades or standards, or evaluating new products.

Knowledge of consumer preferences can set in motion a chain-reaction--e.g., the retailer increases his use of grades and standards to describe his specification order from a packer who in turn increases his effort to purchase the kind of animals from producers that will yield the kind of products consumers desire. Producers respond by selecting, breeding, and feeding the kind of animals that meet the specifications of the market as reflected in prices for certain levels of quality for the different products.

Objective: To provide a continuous intelligence service pertaining to consumer attitudes and preferences for lamb, mutton, and wool.

Research Approaches:

A. Evaluate the knowledge about, and the effect of, grades and standards on consumer purchases of lamb, mutton, and wool products. This should be cooperative with research under RPA 501.

B. Evaluate the consumer response to new products, packages, and methods of handling.

C. Analyze the factors that contribute to lamb and wool purchases and to factors that influence consumers to purchase competing products.

D. Keep abreast of developments in the by-product market, especially hides and fats.

Potential Benefits: Improved market information upon which to base decisions.

NOTE: The allocation of SMY's is included in RPA 505-A.

FARM BARGAINING POWER IN THE MARKETING OF SHEEP AND WOOL

RPA 505-F

Situation: This statement represents the commodity approach to RPA 510. Market power is the ability to influence prices or terms of trade in a way favorable to a business or group. It has long been assumed that, because of the competitive structure of the production process in agriculture, farmers are at a disadvantage in the marketing process and must depend upon competition among buyers to obtain the full value that market conditions justify for their products. Consequently, considerable public enabling legislation has been enacted to strengthen the bargaining and income position of farmers. Examples are the establishment of publicly financed market news, crop and livestock reporting and estimating, and legislation to enable farmers to band together in their buying and selling activities. Farmer cooperatives for years have been involved in helping farmers with problems of bargaining power. Farmers have become increasingly concerned as changes have occurred in the marketing system and they want to participate more. This increased interest has led to self-sponsored programs such as advertising to differentiate their products in the market place. Also Federal and State marketing orders and agreements are long-standing examples of instruments conceived and administered to provide certain elements of bargaining power.

The National Commission on Food Marketing in its 1966 report suggested that there is urgent need for group action by farmers to adjust sales more uniformly, to negotiate with buyers, and to protect themselves against trade practices and abuses of market power to which they are otherwise vulnerable. The costs and benefits of organizing and administering group actions need to be evaluated, as well as the countereffects of these actions on the marketing system and consumers.

Objective: To study and evaluate bargaining power in marketing sheep and wool from the standpoint of equity among participating groups.

Research Approaches:

A. Develop a definition of bargaining power--whether it is militant action, organized procedural activity, some passive role, or various combinations of activity.

B. Evaluate the process of transferring ownership between producers and buyers of sheep and wool with respect to the negotiations, including terms, time, place, weights, grades, amount of information available to both parties, and the resulting equity or lack of it.

C. Study and evaluate the need for a more orderly flow of sheep and wool to market in which the need of the meat packer and wool warehousemen for a steady supply is related to the decisions of producers with respect to time of sale, weight, and quality of animals and wool.

D. Study and evaluate the need for a third party to assume a larger role in grading and pricing sheep and wool in the marketing process--especially if future market structure incorporates more integration, contracting for future sale, or the emergence of a new form of organizational structure that eliminates points of price determination.

Potential Benefits: The information obtained should provide the basis for equity in the market place for all parties involved.

NOTE: The allocation of SMY's is included in RPA 505-A.

PART TWO

ANIMALS OTHER THAN CATTLE, SWINE, AND SHEEP

INTRODUCTION

As stated in the "Preface," this part of the report includes discussions of Angora goats, dairy goats, horses, laboratory animals and pets, mink and rabbits. Although these animals have received very little research attention, they all have a potential for increased contribution to the national economy and society generally. Almost every citizen receives some value from one or more of these animals. Horses, dogs, cats, and other pets are kept largely for recreation or pleasure, however, some are used in research. Laboratory animals are used entirely for research, but investigations as to proper care or to increase their usefulness have been very limited.

All of these animals offer possibilities for increasing rural income and employment. They can provide a source of supplemental income, relieve poverty, consume surplus crops, and provide growing industries that can help increase the national income. Opportunities for economic gains in these species may be greater than for some of the well established animal industries. As a measure of good-will in world affairs we can share our knowledge about these animals with less developed countries.

Dairy goats and rabbits along with sheep are well adapted to expansion in developing countries. These animals can provide an increased supply of high quality protein while largely consuming byproduct feeds which cannot be consumed by humans.

Research Advisory Committee Recommendations

At its last two meetings in 1967 and 1968, the Animal and Animal Products Research Advisory Committee recommended additional research on rabbits and the miniature pig. With respect to rabbits, the Committee emphasized the needs of medical science for laboratory animals and the possibility of a new meat source comparable to poultry. Additional comments included the potential advantages of rabbit production as income opportunities for the elderly and the young, and that it is an enterprise that lends itself to semi-urban areas.

Although the task force assignment did not include swine--the miniature pig may be considered as a laboratory animal, hence, the recommendation of the Advisory Committee is cited below for the purpose of information. A separate task force prepared a report on "Swine."

The development of the miniature pig for medical research stems from the great similarity of swine and human biological processes. Expansion of basic biological knowledge on swine is of tremendous importance in many areas of human research. Increased use of swine in medical research may well relieve some use of pet-type animals in such work but depends on developing a fund of basic biological data comparable to that available on other medical research animals. The needs of human research for an additional nonrodent mammal justify the expansion of basic swine research efforts. Recent breakthroughs in human medicine and surgery (notably organ transplants) point up the timeliness of this need.

In 1965 and again in 1968, the Committee urged more research on diseases of laboratory, pet, and recreational animals. A special need was cited, namely, the responsibility of the Department to administer the Laboratory Animal Welfare Act. Also, there are economic opportunities in industry from the sale of feed and from other needs generated by these animals. There is a great need for more knowledge about the diseases of these animals as their numbers increase through the availability of more leisure time and the movement to suburban and semirural areas takes place.

Research Perspective

As shown in Table 2 on the following page, 77 scientist-man-years in 1966 were classified in the category devoted to research on animals other than cattle, swine, and sheep, practically all in the problem areas of protection and production. A further breakdown of this effort is shown in Table 3. Nearly half the effort was not classified by species. Much of the work not classified according to species appeared to be basic research, judging from the titles of the projects. The more prominent projects pertained to diagnostic techniques, physiology of reproduction, trace elements in nutrition, digestion and metabolism, climate and growth, blood, hormones, viruses, gland extracts, sperm and semen, ovulation and ovarian functions, enzymes, and fluoride deficiency.

The task force recommended increasing this research program to 116 SMY's by 1977. In the statements that follow pertaining to specific species or animal groups, additional research opportunities are pointed out. In addition the work of a basic nature included under this category has a potential for making important additions to present knowledge that can be applicable to the major classes of domestic farm animals and possibly humans. The projected increase by 1977 was not broken down by species for the State research programs. This would have involved making estimates for 50 states with widely divergent interests and resources. The USDA program is presently conducted in 3 research divisions--Entomology, Animal Diseases and Parasites, and Animal Husbandry, which made it possible to project the recommended program for 1977 as shown in Table 4.

TABLE 2. Summary of Inventory and Recommended SMY's for Animals Other Than Cattle, Swine, and Sheep

Research Problem Area	1966 1/			1977 2/			Total Sheep and Other Animals 3/	
	SAES	USDA	TOTAL	SAES	USDA	TOTAL	JC	TF
210 -- Control of Insects	1	1	2	2	2(3)	4(5)	9	10
211 -- Control of Disease	29	1	30	37	4	41	83	83
212 -- Control of Internal Parasites	2	3	5	3(6)	4	7(10)	42	45
213 -- Protection from Hazards and Predators	3		3	4	1	5	14	16
Subtotal - Protection	35	5	40	46(49)	11(12)	57(61)	148	154
310 -- Reproductive Performance	9		9	10(11)	2(3)	12(14)	39	46
311 -- Feed Efficiency	11	2	13	17(14)	3	20(17)	76	73
312 -- Environmental Stress	4	1	5	4(5)	1	5(6)	17	20
313 -- Improved Management Systems		1	1	1(2)	1(2)	2(4)	18	26
409 -- Improved Consumer Acceptance	2	1	3	5	2	7	25	27
Subtotal - Production	26	5	31	37	9(11)	46(48)	175	192
410 -- New and Improved Food Products	6		6	7		7	17	17
Subtotal - Product Development	6		6	7		7	72	72
501 -- Grades and Standards							3	8
505 -- Marketing Efficiency				1(0)		1(0)	8	10
Subtotal - Marketing				1(0)		1(0)	11	18
GRAND TOTALS	67	10	77	91(93)	20(23)	111(116)	406	436

1/ Inventory of Agricultural Research, Volume I, Table I, June 1967.

2/ A joint committee representing the Experiment Station Committee on Organization and Policy, and the USDA made combined projections of SMY's for "Sheep and Other Animals" for 1977. The Task Force divided the projections into categories for "sheep" as shown in Table 1, page 17, and "other animals" shown above. In making allocations between SAES and USDA the pattern or proportion used in the original projection by the joint committee was followed to the extent possible without using fractional numbers. The SMY's recommended by the Task Force are shown in parentheses, if the recommendation differed from that of the joint committee.

3/ Total of SMY's shown in Table 1 and this Table as projected by the joint committee (JC) and the task force (TF). See also comments in the Preface, page vi.

TABLE 3. Distribution of SMY's Reported for "Other Animals" in 1966 Inventory

OTHER ANIMALS	210	211	212	213	310	311	312	313	409	410	505	TOTAL
SAES:												
Angora Goats					.2	1.1			.2			1.5
Dairy Goats												
Horses		4.9	1.1			2.1						8.1
Lab. Animals & Pets	.3	.5		.2	.6	.7						2.3
Mink		.1				.3			2.0			2.4
Rabbits		.1				.1			.2	.4		.8
Fur Animals						1.5						1.5
Prairie Dog							.1					.1
Reindeer	.2											.2
Blue Foxes						.2						.2
Marten						.1		.1				.2
Cattle		.1	.1			.1						.3
Poultry						.1						.1
Not reported by species	1.2	12.3	1.5	.3	2.5	5.2	4.7		.6	.1		28.4
Leukemia		9.9										9.9
Radiation				2.4	.1		2.8	.2				5.5
Radiation & Preservation of Foods: Shellfish, Shrimp, Oysters										5.6		5.6
Subtotal	1.7	27.9	2.7	2.9	3.4	11.5	7.6	.3	3.0	6.1		67.1
USDA:												
Angora Goats	.5											.5
Dairy Goats												
Horses	.5		1.0									1.5
Lab. Animals & Pets			1.0									1.0
Mink		1.0	1.0			2.0	1.0	1.0	1.0			7.0
Rabbits												
Fur Animals												
Prairie Dog												
Reindeer												
Blue Foxes												
Marten												
Cattle												
Poultry												
Not reported by species												
Leukemia												
Radiation; Radiation & Preservation of Foods, etc.												
Subtotal	1.0	1.0	3.0			2.0	1.0	1.0	1.0			10.0

TABLE 4. Summary of USDA Research on Animals Other Than Cattle, Swine, and Sheep

Animals	210		211		212		213		310		311		312		313		409		TOTAL	
	66	77	66	77	66	77	66	77	66	77	66	77	66	77	66	77	66	77	66	77
Angora Goats .	.5	.5							.3		.2		.5						.5	1.5
Dairy Goats ..									.4						.6					1.0
Horses	.5	1.5		2.0	1.0	2.0			.4		1.0						.6		1.5	7.5
Laboratory Animals & Pets		.5			1.0	1.0			.6		.5		.5		.4				1.0	3.5
Mink		.5	1.0	1.0	1.0	1.0		1.0	1.1	2.0	1.1	1.0		1.0	.7	1.0	1.1		7.0	7.5
Rabbits				1.0					.2		.2				.3		.3			2.0
TOTAL	1.0	3.0	1.0	4.0	3.0	4.0		1.0	3.0	2.0	3.0	1.0	1.0	1.0	2.0	1.0	2.0		10.0	23.0

ANGORA GOATS

Historical Trends: The Angora goat probably originated before Biblical times as references to the use of goat's hair are found in the Bible. This goat originated in the high plateau in the area around Ankara (Angora), Turkey. Angora goats were brought into the United States from Turkey in 1849. There were taken westward after the Civil War especially to Texas and California. Texas has been the leading state ever since with over 95% of the Angora goats in the country. Other leading States are Arizona, New Mexico, Missouri, Oregon, California and Utah.

There were 2.4 million Angora goats in the United States in 1920 with an average clip of 3.6 pounds for a total productuon of 8.6 million pounds of mohair. Numbers of goats fluctuated since with highs of 4.5 million head in both 1931 and 1941 and 4.8 million head in 1965. The number declined to just under 4 million in 1968. The average yield of mohair per goat has nearly doubled in the last half century and the total U. S. production nearly tripled while prices fluctuated violently as shown below:

	Average weight of mohair produced per goat	Total mohair produced in the U.S.
1920	3.6 lbs.	8.6 mil. lbs.
1930	4.1	17.6
1940	4.9	21.1
1950	5.2	13.2
1960	6.3	24.5
1968	6.6	26.0

Average Price for mohair received by farmers

1920	1928	1932	1935	1940	1945
--cents per pound--					
24.1	80.1	9.0	36.4	49.7	55.3

1950	1951	1960	1964	1967	1968
76.0	118.0	89.7	94.3	40.9	45.2

The three principal mohair producing countries in the world are the United States, Turkey, and the Republic of South Africa. The relative percentage production of the three is as follows:

	1920	1940	1960	1968
United States	38	49	45	47
Turkey	18	40	40	33
Republic of South Africa ..	44	11	15	20

Imports of mohair into the United States have generally declined to relatively unimportant amounts in recent years. However, exports have tended to increase over the years with half or more of the clip now being exported. Most of the exports are to Europe.

Situation: The Angora goat is kept primarily for mohair production. They complement cattle and sheep in grazing land that is invaded with brushy plants. Goats prefer woody plants and help maintain a better balance of vegetation than when cattle and sheep are grazed without goats. Angora goats are raised almost exclusively in areas where brush invasion is a problem. Thus they are of assistance in control of these noxious plants as well as producing income from resources that would otherwise be unused.

The long locks of mohair give a distinctive appearance to the goat. These grow at the rate of 6 to 12 inches per year and the goats are normally clipped twice each year. Mohair becomes coarser with age and the fine kid mohair is most valuable. Quality and covering of mohair, length of staple, weight of clip per goat, and freedom from kemp and other defects are favored in selection. Open faces are associated with higher kid production. Size, weight for age and number of kids produced are also important performance records.

Total value of mohair produced in 1968 was 11.8 mil. dollars. The average return per goat was about $3. It is obvious that the industry needs to be highly efficient to be profitable. The consumption of mohair depends to a certain extent on style and thus prices can be expected to fluctuate widely. A higher reproductive rate would permit more rapid expansion in times of high prices. It would also permit greater dependence on sale of kids for meat in times of declining prices.

Mohair is a smooth, strong, durable and resilient fiber. It enhances softness and luster in fabrics. Mohair absorbs dye evenly and brilliantly, retains color well, and permits unusual decorative effects. It is mainly used as an apparel fiber but may be used in upholstery, draperies, wigs, switches and rugs. Leather produced from the skin is useful for gloves, purses and novelties.

Flocks of Angora goats vary from farm flocks of under 50 head up to flocks of several thousand head. They are generally shorn twice a year, in the spring from February to April and in the fall from mid-July until October. Kids are generally weaned following the fall shearing. Some protection must be available until 4 to 6 weeks following shearing. They are especially subject to chilling from cold wet rains until they grow sufficient hair for protection and heavy death losses may occur. Sometimes a "cape" or strip of mohair, 3 to 4 inches wide is left down the back of the goat at the spring shearing for protection.

Angora does breed in the fall and kid in the spring after a five-month gestation. Twins are common and kidding percentages average in the range of 110 to 185. From 10 to 35% or more does may fail to kid. Abortion is a common cause of loss and reaches a peak at about 110 days after conception. It is thought to have an endocrinological or genetic basis rather than an infective one.

External parasites include several species of lice which may be controlled by dipping or spraying with recommended insecticides. The stomach worm is the most troublesome internal parasite, particularly in wet years.

Objectives: To bring about technological advances sufficient to permit maintenance and possible expansion of the mohair industry. To increase reproductive and feed efficiency of the Angora goat. To reduce Angora goat losses particularly from chilling. To increase the efficiency of production and quality of mohair produced. (See also pages 50-55.)

Research Approaches:

A. Study the basic physiology of initiation of parturition to advance knowledge of this phenomenon and to develop a means of controlling abortion in Angora does.

B. Investigate genetic, environmental and management factors associated with abortion in goat flocks.

C. Use the goat as an experimental animal to study the physiological pathways of photoperiodism and possibly suggest means of bringing about gonadotrophin release by artificial means.

D. Study neuro-hormonal relationships in goats and determine their relationship to production efficiency.

E. Increase the number of offspring weaned per doe through more thorough study of all aspects of reproduction.

F. Identify and expand through breeding those individuals which are the most efficient convertors of feed to meat, milk and fiber.

G. Develop new and improved procedures for evaluating and increasing feed efficiency.

H. Determine the physiological changes which occur when animals are subjected to low temperature stress and determine the influence of various management practices to to freeze losses.

I. Develop practical protective coatings adequate to prevent off shear losses without adverse effects on the animal or the fiber produced.

J. Investigate the design and use of simple, practical shelters and the grazing behavioral patterns of the species in order to insure shelter use in critical times.

K. Improve mohair production through breeding for heavier fleeces and through selection for improved quality of mohair.

L. Determine how finer mohair can be retained with advancing age and increasing fleece weight.

M. Improve the production of kids for meat.

Potential Benefits: A more profitable Angora goat industry made possible by more efficient production. More effective utilization of important range farm resources. High quality mohair products would be available at a reasonable cost to consumers. Chevon would be more available to consumers. Considerable basic information would accrue from these studies which would have potential benefit to sheep and livestock production as well as to a broad area of science.

DAIRY GOATS

Historical Trends: The dairy-goat industry, although relatively small has continued to develop in the United States. Dairy-goat organizations and persons acquainted with the use and quality of the products of these animals have contributed much to the progress of the industry. In Switzerland, Italy, Germany, France, Norway and Spain the domestic goat from earliest times has been an important provider of milk and other food. Immigrants from these and other countries endowed with experience and appreciation of the dairy goat have emphasized the essential place of the dairy goat in our agricultural economy.

The present breeds of dairy goats have been imported relatively recently into the United States although earlier importations may not have been recorded. The Toggenburg breed was imported first from England in 1893 and from Switzerland in 1904 and 1905. The Saanen breed also came from Switzerland by way of Canada in 1904. Nubian goats were imported from England in 1896. Later in 1909 some came from France by way of Mexico. The French Alpine was first imported from France to California in 1922. Some other types were brought in such as the Murcian from Spain and the Norska from Norway. The common or American goats found in many sections of the United States are of mixed origin. These are generally poor milkers but are quite prolific. The Toggenburg, Saanen, French Alpine and Nubian all have high milk production records and are generally favored for dairy purposes.

Situation: About 1 million goats are kept for milk production in the United States. About 95% of these animals are kept in herds of less than 10 animals and are used primarily for milk for family use. Many are found in the vicinity of large cities. Less than 1% are found in herds of over 80 animals. The average dairy goat produces about 1,000 pounds of milk per year. Dairy goats will produce abundantly under a wide variety of climatic and feed conditions.

Goat's milk is a healthful and nutritious food. The small fat globules and the soft curd of goat's milk contribute to its ease of digestibility. Some persons who are allergic to cow's milk can consume goat's milk readily. In a great many cases, goat's milk has proven especially valuable for infants and invalids. It is also used for making special varieties of cheese. Goat's milk offers a ready and feasible way of improving the diets of people in poverty and in developing countries. It is essential to human diets in many parts of the world. The meat from dairy goats is a nutritious by-product which adds high quality protein to the diet.

Milk production of superior dairy goats has declined in recent years. This lack of progress is attributed to a nearly total absence of scientific effort on goat production research. The United States has exported considerable

numbers of dairy goats to foreign countries and no doubt can continue to do so especially if productivity is improved. The industry is declining in the U. S. and may not survive unless new technology is provided. Research could easily lead to a doubling of milk yields from dairy goats.

Objective: Obtain knowledge and devise procedures and techniques to improve production of milk and number of offspring from dairy goats.

Research Approaches:

A. Improve milk production of dairy goats through increased knowledge on performance testing, selection, crossbreeding, use of exotic breeds and use of artificial insemination.

B. Increase the numbers of offspring per doe produced by dairy goats through increased knowledge about inheritance of reproductive rate, physiology of reproduction, prevention of abortion, and prenatal loss, and improvement of fertility.

C. Develop improved management practices for the efficient production of dairy goats and goat milk.

Potential Benefits: Decreased costs of production and increased returns to goat producers, lower costs of goat milk to consumers, increased export markets for goats and increased supply of high quality protein to developing countries.

HORSES

Historical Trends: Horses roamed the Great Plains area of the United States in prehistoric times but none remained when Columbus arrived. Apparently those which migrated to Asia and Europe survived and the horse became extinct in the Americas during the ice age. Horses appear to have been first domesticated in Central Asia and they have been used for centuries throughout the world as a source of power and a means of transportation. Of course they were widely used for military purposes.

The number of horses in the United States increased up to 1915 when there was a record number of over 21 million head. With the advent of mechanized power and transportation there was a dramatic decline in horse numbers. By 1960 the 3 million remaining horses marked the lowest level since the Civil War or since the beginning of the Agricultural Census. This sharp decrease in the use of horses for draft and transportation has had a far reaching effect on American Agriculture. It has been estimated that from 35 to 75 million acres of land that formerly produced feed for horses was released for other purposes.

The horses which remained were used for stock horses on western cattle ranches, rodeo competition, horse shows, racing, pleasure, and recreation. Use for racing, pleasure, and recreation seems to be steadily expanding. Horse projects are among the most popular in 4-H Clubs.

The Remount Service of the United States Army, established in 1921 by Act of Congress was active in breeding horses for military use. This Service was transferred to the Department of Agriculture in 1948 after which a liquidation of program took place.

Situation: The increase in leisure time and the release of a greater proportion of income for recreational purposes is leading an increasing number of Americans to turn to horses. Horse racing is one of the more important spectator sports. Taxes taken by States from wagering at race tracks amount to hundreds of millions of dollars annually. Horse riding is a rapidly increasing source of recreation. A great variety of amusements range from horse shows, and trail riding, and club work to rodeos and racing.

Growth and development of a strong light-horse industry has great promise as a means of improving income opportunities in rural areas and communities and by affording more citizens with recreational opportunities. While accurate inventories are not available, indications are that the number of light-horses (800 to 1,200 lbs.) in the United States has doubled in the last 7 years and numbered 6.4 million in 1967. At this rate we can expect 8 million by 1972 and 10 to 12 million by 1980 at which time approximately 82 million or more people will "saddle-up" at least once a year. Light-horse 4-H Club projects have increased from 37,531 in 1959 to 152,273 in 1967.

Depressed rural areas offer good opportunity for light-horse husbandry. Light-horse husbandry can be readily adapted to most of these environments, provide additional income to rural families, and contribute to the economic growth of rural communities. However, the growth of this industry is manacled by a host of inefficiencies. From 50 to 60 percent of the mares bred fail to produce foals. Little has been accomplished in determining nutrient requirements of light-horses so that improved rations can be developed and savings made in feed costs. The cost of maintaining a registered barren mare can easily exceed $1,000 annually. Eighty-five percent of horse work is still hand labor. In genetics, only coat color has been studied and even this was not done thoroughly. This industry is practically untouched by the rewards of modern technological improvements.

The biology of external parasites of horses is incompletely known and this lack of knowledge seriously hinders development of satisfactory control measures. Insects and ticks are common intermediate hosts or mechanical transmission agents for equine piroplasmosis of horses, and as such, constitute a serious potential hazard in areas where diseases and parasites are endemic.

Major disease and parasite problems confronting the horse industry are equine infectious anemia (swamp fever), equine rhinopneumonitis (virus abortion), respiratory diseases, internal parasites (especially strongyles), and equine piroplasmosis (a tick-transmitted protozoan infecting the red blood cells). Recent reports indicate that cases of equine encephalomyelitis are on the increase. Currently major research efforts are being directed to the problems of infectious anemia and piroplasmosis.

Practically no research has been devoted to increasing the satisfaction of the owners and users of horses. Horses with superior dispositions command higher sale prices than less gentle horses. Still little is known of how to produce or manage horses so they will be more gentle and still have the spirit desired by many. Development of procedures to reduce accidents is needed. Reduction in occurrences of disorders and unsoundnesses could increase owner satisfaction. Methods of management, feeding, and care are needed to fit modern conditions

Research on horses has been neglected possibly because the industry is not food oriented and because horses are largely used for recreation and sport. However research would not only aid those who make a living from horse production but it would also add to the satisfaction and pleasure of the millions of consumers who use horses in one way or another. The horse industry of today is reported to involve an annual expenditure of 6 billion dollars ranging from vitamins and minerals to saddles and horse trailers. Furthermore the industry is growing rapidly. Research could strengthen the position of the horse in the national economy.

Objectives: To reduce losses from insects, diseases and parasites of horses, to increase reproductive efficiency, to increase feed efficiency and avoid digestive disorders, to develop efficient production practices and to develop procedures of feeding, management and care to improve speed, endurance, disposition, temperament, physical soundness, susceptibility to lameness or disease and satisfaction of the horse owner or user.

Research Approaches:

A. Investigate insects, diseases and parasites affecting horses in order to develop more effective preventive and control measures.

B. Determine the causative factors and ways to improve reproductive efficiency.

C. Develop improved methods for handling semen and for artificial insemination of horses.

D. Determine the basic nutritional requirements of the horse.

E. Develop improved feeding and management practices to insure against digestive upsets and against lameness and unsoundnesses of the feet and legs.

F. Improve the disposition of the horse through more effective management practices.

G. Identify and improve meaningful factors involved in owner or user satisfaction.

Potential Benefits:

A. Reduce the cost of raising horses.

B. Provide more adequate horses for recreational use.

C. Contribute toward rural development and income opportunity.

D. Contribute toward the maintenance of desirable rural-urban balance through increased recreational facilities.

E. Contribute to technology that would lead to greater production efficiency in other farm animals.

F. Make available more and better horses that contribute to a wholesome outdoor recreational activity as well as better horses for farm and ranch use.

G. Public satisfaction and recreational needs would be better fulfilled through more adequate and humane handling and care for horses.

LABORATORY ANIMALS AND PETS

Historical Trends: Man has always enjoyed the company of an infinite variety of animals. Many animals which are used as pets are also used as laboratory animals, no doubt in part because of their ready availability. This is especially true of cats and dogs. This has led to concern of the public regarding the care of laboratory animals.

Situation: A National Research Council survey for 1966 shows that over 58 million research animals were used in 1966. The actual use was, undoubtedly, higher as only 60 percent of the questionnaires were returned. Questionnaires were received from 523 of 874 known breeders of laboratory animals or dealers and from 919 of 1,506 known users of laboratory animals. A total of over 130 different kinds and species of laboratory animals were involved. These included 37 million rodents, 363 thousand rabbits, 52 thousand primates, 1.8 million birds, 13 million marine animals, 415 thousand dogs, 143 thousand cats, 4 million frogs, 606 thousand insects, and about 1/2 million other animals. The total value of experimental animals is estimated at about $50 million. The number of animals used for pets is not known but it is estimated that there are about 26 million dogs, 32 million cats, and many other animals. The total value of pets probably exceeds one billion dollars. In many cases, pets are considered as a part of the family and are priceless.

The public is concerned about whether the care of laboratory animals is adequate and humane as evidenced by the bills considered by Congress to regulate their use and care. The Laboratory Animal Welfare Act of 1966 assigned to the Department the responsibility for developing and enforcing the necessary regulations and standards for laboratory animal care. The development of these regulations and standards, however, raised several controversial questions about which little or no factual information is available. Research answers are needed to determine requirements for space, temperature, exercise, water, bedding, feeding devices and methods, waste disposal, sanitation and shipping (space and temperature). Nutritional requirements for rabbits, hamsters and guinea pigs are not well known.

There are wide differences of opinion as to what adequate and humane care constitutes, as many people judge animals as they would themselves. Clearly defined and well substantiated standards for the care of laboratory animals are not available, although considerable information has been accumulated. Objective criteria are needed for measuring the well-being of laboratory animals. Then standards for care need to be developed which will provide for optimum comfort for the animals.

Failure to adequately care for experimental animals increases losses or reduces the fitness of the animals for laboratory use. On the other hand, excess care and unnecessary procedures are an attempt to avoid criticism of inhumane treatment and will increase the cost and reduce the efficiency of research. Research is needed to determine the handling, nutrition, and equipment requirements for the normal well-being of these animals.

Objectives: Develop knowledge and economically feasible procedures and techniques for establishing more adequate standards for the care of laboratory animals and pets and devise procedures for optimum handling and efficient care.

Research Approaches:

A. Increase fitness of laboratory animals and pets through disease and parasite prevention and control and through improved breeding, feeding and management practices.

B. Improve the care of laboratory animals and pets through identification of optimum environmental factors and through development of improved management practices.

C. Improve the usefulness of laboratory animals and pets through investigation of genetics, reproduction and nutrition to increase their adequacy for research and owner satisfaction for pets.

Potential Benefits:

A. Reduce the cost of laboratory animal care.

B. Increase the value of laboratory animals as experimental animals.

C. Reduce the cost of rearing and maintaining animal pets.

D. Objective measures will permit reasonable standards and will provide basis for determining whether such animals are cared for adequately and humanely.

E. Greater public satisfaction with use of animals for research.

F. Improve quality of animals available for research.

G. Greater owner satisfaction from pets.

MINK

Historical Trends: The raising of fur animals on ranches or farms was started in this country about 1905 but did not become important until the late 1920's. Mink were trapped from the wild and were kept in pens. Some transfer of mink from wild to domestic conditions still continues. The principal growth of mink farming has occurred since the end of World War II. About 2 million pelts were produced in 1950. Production had increased to over 6 million in 1960 and to over 8 million currently. However, production seems to be leveling off now. There has been a decrease in the wild catch of mink along with the increase in ranch raised mink. In 1955 the wild catch was 14% of total production as compared with 4% in 1965. In recent years there has been a reduction in the number of mink ranches with an increase in the number of pelts per ranch. The average number of pelts per ranch was 1,845 in 1965.

There has been an increase in the number of pelts imported to a total of about 5 to 6 million pelts annually. About one million pelts are exported. The increase has been particularly notable from Scandinavia which furnishes a majority of the imports. The remaining imports come from Europe, Canada, and Japan and elsewhere. About 40% of the pelts consumed in the United States are imported.

In the early years of mink production a number of mutant genes were discovered which resulted in colors which varied from the normal light brown color of wild mink. These genes in various combinations have produced a wide range of colors from almost white to almost black and with many other attractive shades and colors in between.

Mink apparel is the dream of every well dressed woman. Garments made of mink have been used by royalty throughout the ages. Mink are preferred to other furs as wearing apparel because of their beauty, lightweight, versatility, durability and ease of styling.

Situation: Mink are produced on over 4,000 ranches located primarily in the Northern States. About 8 million pelts are produced annually for a gross income of about $160 million. Mink have an important place in the American economy because they utilize by-products of the meat, poultry and fishing industries and they consume surplus feeds. Employment is provided for about 10,000 people on ranches and many more in related industries. While mink furs are a luxury product, they contribute importantly to natural beauty and quality of living.

The mink industry suffers from intense foreign competition because of lower feed and labor costs in the Scandinavian and other countries. American pelts are superior in quality but hardly enough so to offset the higher cost of production. Continued improvement in efficiency of production and in quality of pelts produced is essential for the continuation of a viable mink industry.

Numerous infectious and non-infectious disease problems are encountered by mink ranchers. One of the major problems occurring in recent years has been Aleutian disease. Currently, the disease is thought to be caused by a virus associated with genetic susceptibility in certain mink bred for pelt colors which vary from the natural dark of the wild mink. "Wet belly" is a problem of concern to the industry. It is a condition where the abdominal fur is soiled and damaged by urine. Infant mortality causes serious losses to the industry. Recently a problem designated as mink encephalopathy has occurred on certain mink ranches.

Reproduction is of primary importance to the mink industry. Mink are mated in March and implantation is delayed until early April. The kits are born in May after a gestation period of 40 to 55 days of which the development of the fetus requires only the last 30 days. Approximately 10 eggs per female are fertilized, but only about 5 young are whelped and about 10% of these die. About 85% of the female have young. Approximately 3.5 pelts are marketed per breeding female. The entire reproductive cycle from mating to weaning requires about 5 months. The reproductive period for mink is about 4 years, but most are replaced after 2 years. It seems obvious that there are tremendous opportunities to increase the reproductive efficiency of mink.

The economical and efficient production of mink is contingent upon maximum production per unit of feed. Large litters, heavy weaning weights, continous and rapid growth of kits and economical maintenance of breeding animals make for profit and are largely the result of proper nutrition. Mink foods are blends of ingredients which are composed of various byproducts of the meat packing, poultry and fishing industries plus surplus cereals. Despite considerable information on practical feeding, little is known of the mink's exact nutrient needs. The basic character of the ration depends on availability, price, freshness and quality of the key food ingredients. In most regions a combination of meat and fish provides the foundation on which mink rations are built. Under certain conditions of drying and reconstitution, experimental dry diets will give weight gains, palatability, digestibility, feed efficiency and fur growth comparable to the same diet fed in the conventional manner but with lower cost, reduced labor requirements and less difficulty with storage and spoilage. Further work, however, is needed in the determination of nutrient requirements and relationships and in the formulation and feed processing techniques which will bring much needed improvement in feed efficiency to the mink rancher.

Reproduction, development, and priming of the pelt in mink appear to be controlled by climatic factors, particularly light. A thorough understanding of the mechanisms by which this is accomplished could result in producing two crops of kits per year and might also result in speeding up the pelt development process or be used to advantage in improving pelt quality.

Selection aids and breeding systems for mink have emphasized the production of various color phases which depend on various mutant genes and their combinations. Investigations of blood groups have shown that certain types are incompatible and when in combination appear to result in prenatal death. Little is known of genetic parameters for reproduction, growth rate, development of prime pelt and fur density, the main component of fur quality other than color. Selection has been practiced largely for color and color pattern and elimination of defects. Little selection has been practiced for productivity and quality of product other than color.

Quality of the mink pelt is determined not only by the natural beauty and color but also by the density and luster of the fur. Domestic skins are generally superior to foreign pelts but continued research is essential to maintain this advantage. Valuations placed upon furs by the trade are determined subjectively on density of fur cover, luster, uniform appearance and texture of the fur, uniformity and depth of color as well as suppleness and pliability of the leather. The development of objective measures of quality would enhance efforts to improve fur quality.

Objectives:

A. Improve methods for diagnosis, control and elimination of diseases of mink.

B. Improve reproductive efficiency in mink through reduction of infertility, increase in litter size, development of methods for artificial insemination, transfer of eggs and control of sex.

C. Increase feed efficiency for mink production through reduction in feed costs, definition of feed requirements and development of practical dry diets.

D. Determine the effects of temperature, light and length of day on reproduction and fur growth to use these factors in bringing about a second complete reproductive cycle each year and to increase the efficiency of fur growth and the quality of the pelt produced.

E. Develop knowledge and practical procedures to increase productivity in mink through effective selection methods.

F. Develop practical production systems to increase the efficiency of mink production.

G. Improve quality of mink pelts produced by developing objective measures of pelt quality and by determining the effects of breeding, feeding, and management practices on these measures of pelt quality.

Potential Benefits: Benefits will include lower production costs and higher productivity resulting in marked gains in efficiency. Facility needs will be reduced. Mink fur will be more readily available at lower cost to the consumer. The domestic industry will be better able to meet foreign competition. Export markets for breeder animals can be expanded. Feed resources not useful to humans will be more effectively utilized. New technologies will contribute useful knowledge for other farm animals, laboratory animals, pelts and man. Most important is the contribution to natural beauty, quality of living and to the pleasure and satisfaction of mankind.

RABBITS

Historical Trends: Early in this century promotion schemes in connection with the raising and selling of Belgian Hares led the public to become rabbit conscious. Breeds of rabbits formerly raised in other countries were brought into the United States and supplied the foundation stock for the rabbit industry. Six breeds of rabbits have originated in the United States. These include the American Blue, American Sable, American Silver Fox, Californian, New Zealand and Satin. The White New Zealand is probably the most common.

The production of domestic rabbits has declined considerably in the past 20 years. This was due to (1) the improvement in other meat sources after shortages during World War II; (2) the effect of the revolution in the poultry industry with resultant tremendous decreases in the prices of poultry which is the prime competitor of rabbit meat; (3) the transition of the Southern California economy from rural to urban which has displaced production areas or eliminated them altogether; and (4) the decline of the fur market and uses of natural animal fibers due to the development of man-made fibers, and the trend of fashions.

Rabbits have been raised for a variety of purposes in all parts of the United States. The center of production in Southern California developed in the 1920's or earlier but in recent years has shifted to Arkansas. Rabbits have always been raised for meat and skins but the latter has become of lesser importance in more recent years. More recently the production of biological materials from rabbits has increased.

Situation: The domestic rabbit compares favorably with other meat producing animals and poultry in its conversion of feed crops into meat for human consumption. It lends itself as a source of supplemental income as the care of rabbits may be organized within either a 5 day week or a part time schedule and the work is not arduous. Rabbits can easily be raised in suburban areas. They are particularly suited to areas of rural proverty because of their production of high quality protein at low cost. For this same reason they might be particularly useful in developing countries. There may be a possibility for this infant industry to develop into a major food industry. Rabbit projects in 4-H clubs have demonstrated the feasibility of production by young persons. Likewise, elderly persons could take advantage of the low capital cost to start a business. The small size and the gentle nature of the rabbit are factors that make handling suitable for young and old. Rabbit wastes are easily handled in an economical way so that there is little liklihood of the operation becoming a community nuisance.

Rabbit production is basically quite efficient. A doe will produce 4 litters a year with about 8 young weaned each. Young fryer rabbits will weigh from 4 to 5 lbs. at 2 months of age and will yield over 50% of carcass meat of which about 80% is edible. A pound of marketable fryer rabbit will require

from 2-1/2 to 3-1/2 lbs. of feed or approximately 100 lbs. of feed for a doe and litter of 8 to marketing of the young at 2 months of age. Labor requirements averaged 6.4 hours per doe per year in one study. Investment costs averaged about $35 per doe in 1962-63. In this study, average returns per doe was $29.59 with costs of $23.04

The total commercial processing of rabbits for meat is estimated at about 4 million fryers annually. In addition there are from 50 to 100 thousand hobby producers and fanciers which produce another 4 to 8 million fryers. Thus there would be a total production of about 8 to 12 million fryers with an estimated return to producers of $10 million annually.

Rabbit production is confronted with disease and parasite problems. These include pasteurellosis, salmonellosis, non-specific enteritis, coccidiosis and most recently epizootic abortions. Reproduction is normally very high in rabbits but a marked reduction in reproductive rate occurs in the fall months. Feed efficiency is high but further advances are undoubtedly possible. Environmental stresses occur particularly from high temperatures. Genetic improvement both from selection and from crossbreeding has great potential. Finally improvement in meat quality deserves further attention.

Rabbit production is important in the support of medical research and other basic life science research. Animal numbers are far below potential demands for medical research and teaching. The demand for biological materials from rabbits appears to be continually expanding.

The immediate research needs are for more information on methods of detection and control of rabbit diseases and parasites, methods for more efficient production, and methods for improving the quality of the animals. Specifically, the biomedical research use of these animals would be greatly enhanced by production of disease- and parasite-free rabbits of greater animal to animal uniformity. Research on the elimination of "snuffles" in rabbits may well provide valuable spin-off information on the control and elimination of shipping fever in cattle.

Objectives: To increase the efficiency of rabbit production through improved disease prevention and control, elimination of the fall breeding problem, improved feed efficiency, more efficient management and breeding practices and development of better meat quality.

Research Approaches:

A. Develop methods of preventing and controling important disease and parasite problems such as enteritis and coccidiosis.

B. Improve reproductive efficiency of rabbits through elimination of the breeding depression in the fall.

C. Increase the efficiency of utilization of low cost feeds.

D. Improve efficiency of rabbit production through more effective selection and cross breeding practices.

E. Improve the quality of rabbit meat and biological materials produced.

Potential Benefits: Increased variety would be added to the meat diet. High quality protein food would be more available to low income people and to people of developing countries. An added source of income would be provided for rural poverty areas. Biomedical research needs would be more fully met.

APPENDIX A. Brief Description of Public Services and Regulations

a. Animal inspection and quarantine

A national protective system, called Animal Inspection and Quarantine, first established in 1865, guards the U. S. livestock industry by regulating the importation of animals and poultry, animal and poultry products and byproducts, hay, straw, and animal casings--the primary objectives being to keep out foreign diseases that might imperil our livestock industry.

b. Inspection at public stockyards

Federal inspection is a service provided at public stockyards located in the major marketing centers throughout the United States. Since its establishment in 1890, public stockyards inspection has aided in the control or eradication of many serious animal plagues. Federal inspectors examine all livestock arriving at public stockyards, segregate diseased animals and see to it that they are safely disposed of, supervise cleaning and disinfection of vehicles, pens, and premises contaminated by diseased animals, notify State of origin of diseased livestock discovered by inspection, supervise other animal health activities, and issue certificates for interstate movement of livestock found to be apparently free from communicable diseases.

c. Meat inspection

In 1906, Congress enacted the Meat Inspection Act. It requires Federal supervision of the cleanliness, wholesomeness, and labeling of fresh and processed meat food products designated for sale in interstate commerce. Inspection begins with the live animal before slaughter and continues through examination of all parts of the carcass. Supervision is maintained throughout each stage of curing, canning, and other processing.

d. Packers and Stockyards Act

This Act was passed by Congress in 1921. It was designed to preserve free and open competition for livestock and meat so that each will bring its full and true value in the marketplace. The Act was later amended until it now extends to all country dealers, buying stations, and auction markets if they handle any interstate business. With modern transportation almost all business has become subject to the Act. In 1940, 199 markets in the U. S. were posted and in 1950, 308, and by 1961 this number had grown to over 2,200.

e. Market news

Reporting of wholesale meat markets was initiated at Boston, New York, and Philadelphia in 1917. The next year the first livestock market news reports were issued at Chicago. This service has grown into a major informational aspect of marketing work to provide quick, accurate reporting of market conditions for the benefit of farmers, distributors, and consumers.

f. Standards and grades

The Secretary of Agriculture is authorized to develop and improve standards of quality, condition, quantity, and grade of agricultural products in order to encourage uniformity and consistency in commercial practices. He is also authorized to inspect and certify the class, quality, and condition of agricultural products so that they may be marketed to best advantage, that trading may be facilitated, and that consumers may be able to obtain the quality product they desire. The first United States standards for grades of raw or greasy wool were established by the Secretary of Agriculture in 1923. In 1926 a standard series of 12 official grades were established. The basis for all of the standards was fineness, or diameter of fiber. Later revisions occurred in 1940 and 1955 including distribution requirements as well as fiber diameter. Revised standards for grades of wool top became effective January 20, 1969. Official standards for grades of lamb and mutton carcasses were established February 16, 1931. They were amended in 1940, 1951, 1957, and 1960. The foregoing have been quality grades. On March 1, 1969 yield grade standards for lamb carcasses and slaughter lambs were established on a voluntary basis, the same as for the quality grades. The yield grades for slaughter lambs reflect the expected yield of retail cuts ultimately produced from its carcass. The USDA conducts no official grading service for live animals.

APPENDIX TABLE 1. Trends in U. S. Per Capita Consumption of Fibers 1940-1968

Fibers	1940	1945	1950	1955	1960	1965	1968
	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Wool	3.2	4.3	4.6	3.0	3.0	2.7	2.3
Cellulosic:							
Rayon and Acetate	3.7	5.5	8.6	8.4	5.8	8.1	8.6
Cotton	28.9	30.4	29.4	25.4	23.4	24.0	22.0
Noncellulosic:							
Man-made Fibers	--	0.3	0.9	2.6	4.3	10.3	18.0
TOTAL	35.8	40.5	43.5	39.4	36.5	45.1	50.9